

PAST CE BOARD EXAM:

The result of the sieve analysis is shown below.
Determine the following:

- a) Percentage of Gravel
- b) Percentage of Sand
- c) Percentage of Silt and Clay
- d) Effective Diameter
- e) Average Grain Size
- f) Uniformity Coefficient
- g) Coefficient of Gradation or Curvature
- h) Sorting Coefficient
- i) Graph of Soil Particle Size Distribution
- j) Classify the soil according to USDA
- k) Classify the soil according to USCS
- l) Classify the soil according to AASHTO

Take:

Liquid Limit = 30%

Plastic Limit = 20%

Sieve No.	Diameter of Opening, mm	Mass of Soil Retained on each sieve, g
4	4.76	5
8	2.38	45
10	2.00	65
20	0.84	92
40	0.42	152
60	0.25	115
80	0.180	212
100	0.149	63
200	0.074	32
PAN	-	14

PAST CE BOARD EXAM:

The result of the sieve analysis is shown below.
Determine the:

- a) Percentage of Gravel
- b) Percentage of Sand
- c) Percentage of Silt and Clay

Solution:

$$\frac{795 - 5}{795} \times 100 = 99.37\%$$

$$\frac{795 - 50}{795} \times 100 = 93.71\%$$

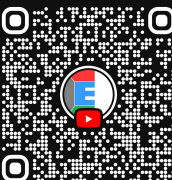
$$\frac{795 - 115}{795} \times 100 = 85.53\%$$

$$\frac{795 - 207}{795} \times 100 = 73.96\%$$

Sieve No.	Diameter of Opening, mm	Mass of Soil Retained on each sieve, g	Cumulative Mass Retained, g	Percent Finer, %
4	4.76	5		
8	2.38	45		
10	2.00	65		
20	0.84	92		
40	0.42	152		
60	0.25	115		
80	0.180	212		
100	0.149	63		
200	0.074	32		
PAN	-	14		
		$\Sigma = 795$		

$$\frac{(795 - 781)}{795} \times 100\% = 1.76\%$$

$$\frac{(795 - 795)}{795} \times 100\% = 0\%$$





PAST CE BOARD EXAM:

The result of the sieve analysis is shown below. Determine the:

- a) Percentage of Gravel
- b) Percentage of Sand
- c) Percentage of Silt and Clay

Solution:

Gravel is the percentage Retained on Sieve No. 4, thus:
$$= 100\% - (\text{Percent Passing Sieve No. 4})$$
$$= 100\% - 99.37\% = \mathbf{0.63\%}$$
Ans.

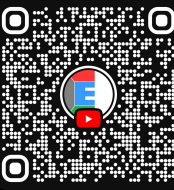
Sand is the percentage Passing No. 4 but retained on No. 200, thus:
$$= (\text{Percent Passing Sieve No. 4}) - (\text{Percent Passing Sieve No. 200})$$
$$= 99.37\% - 1.76\% = \mathbf{97.61\%}$$
Ans.

Silts and Clay is the percentage Passing No. 200:
$$= \mathbf{1.76\%}$$
Ans.

Sieve No.	Diameter of Opening, mm	Mass of Soil Retained on each sieve, g	Cumulative Mass Retained, g	Percent Finer, %
4	4.76	5	5	99.37
8	2.38	45	50	93.71
10	2.00	65	115	85.53
20	0.84	92	207	73.96
40	0.42	152	359	54.84
60	0.25	115	474	40.38
80	0.180	212	686	13.71
100	0.149	63	749	5.79
200	0.074	32	781	1.76
PAN	-	14	795	0

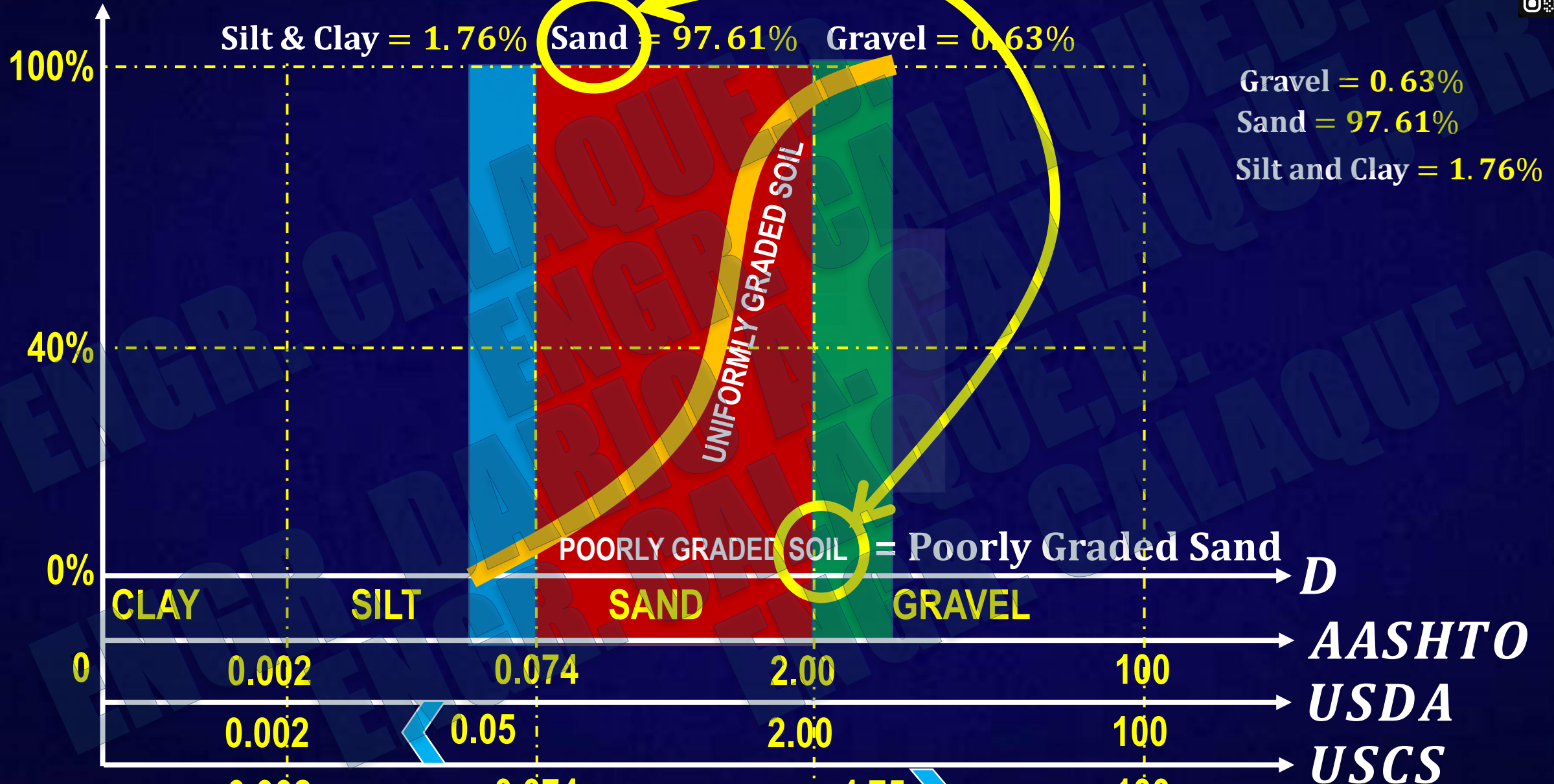
GRAVEL (USCS)

SAND (USCS&AASHTO)



%*Finer*

SOIL PARTICLE SIZE DISTRIBUTION



PAST CE BOARD EXAM:

The result of the sieve analysis is shown below.
Determine the:

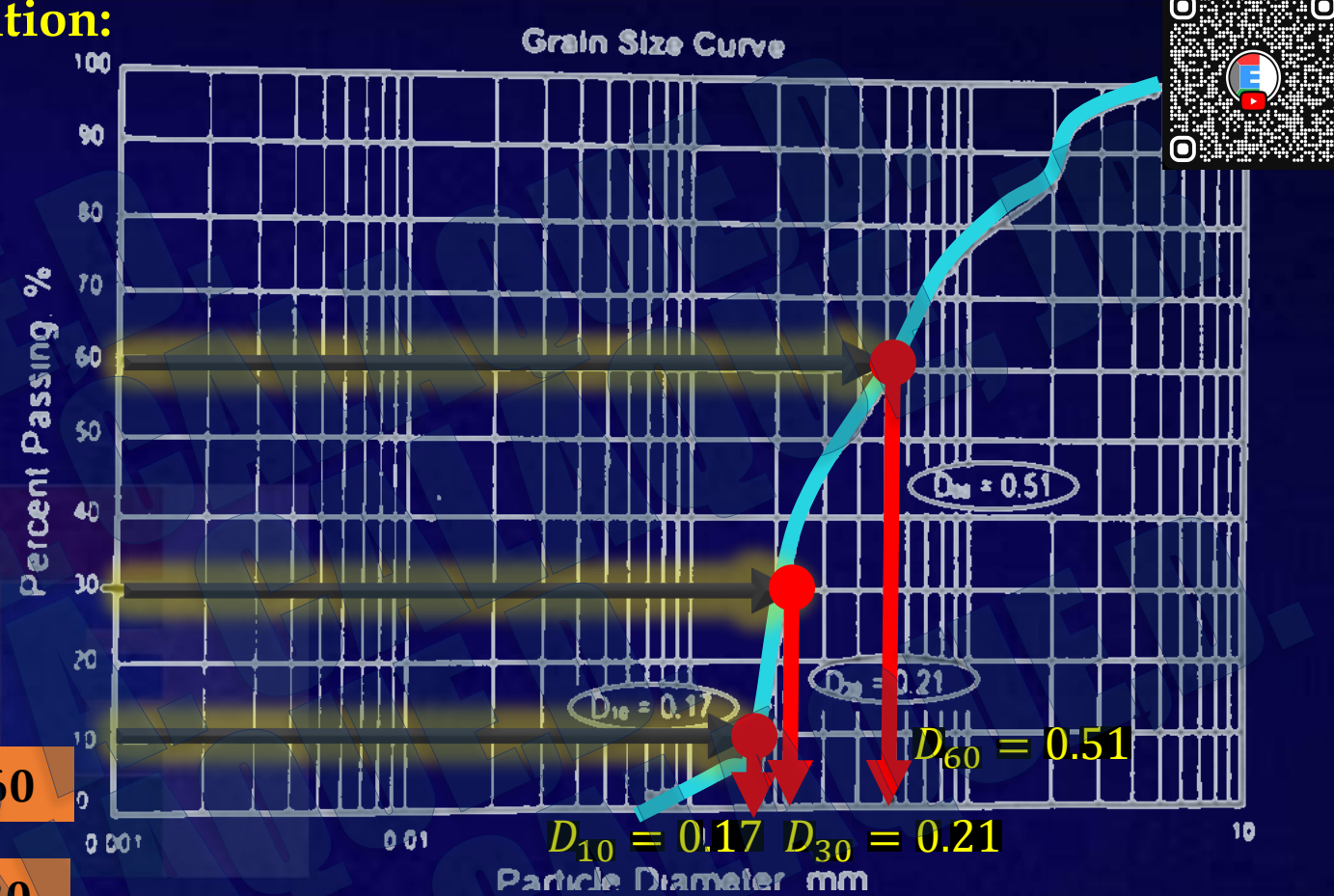
- a) Effective Diameter
- b) Average Grain Size
- c) Uniformity Coefficient
- d) Coefficient of Gradation or Curvature
- e) Sorting Coefficient

Sieve No.	Diameter of Opening, mm	Percent Finer, %
4	4.76	99.37
8	2.38	93.71
10	2.00	85.53
20	0.84	73.96
40	0.42	54.84
60	0.25	40.38
80	0.180	13.71
100	0.149	5.79
200	0.074	1.76
PAN	-	0

Gravel = 0.63%
Sand = 97.61%
Silt and Clay = 1.76%

Solution:

D60
D30
D10



Coefficient of Uniformity

$$C_u = \frac{D_{60}}{D_{10}} = \frac{0.51}{0.17} = 3$$

Coefficient of Gradation or Coefficient of Curvature

$$C_c = \frac{(D_{30})^2}{D_{60} \times D_{10}} = \frac{(0.21)^2}{0.51(0.17)} = 0.509$$

PAST CE BOARD EXAM:

The result of the sieve analysis is shown below.
Determine the:

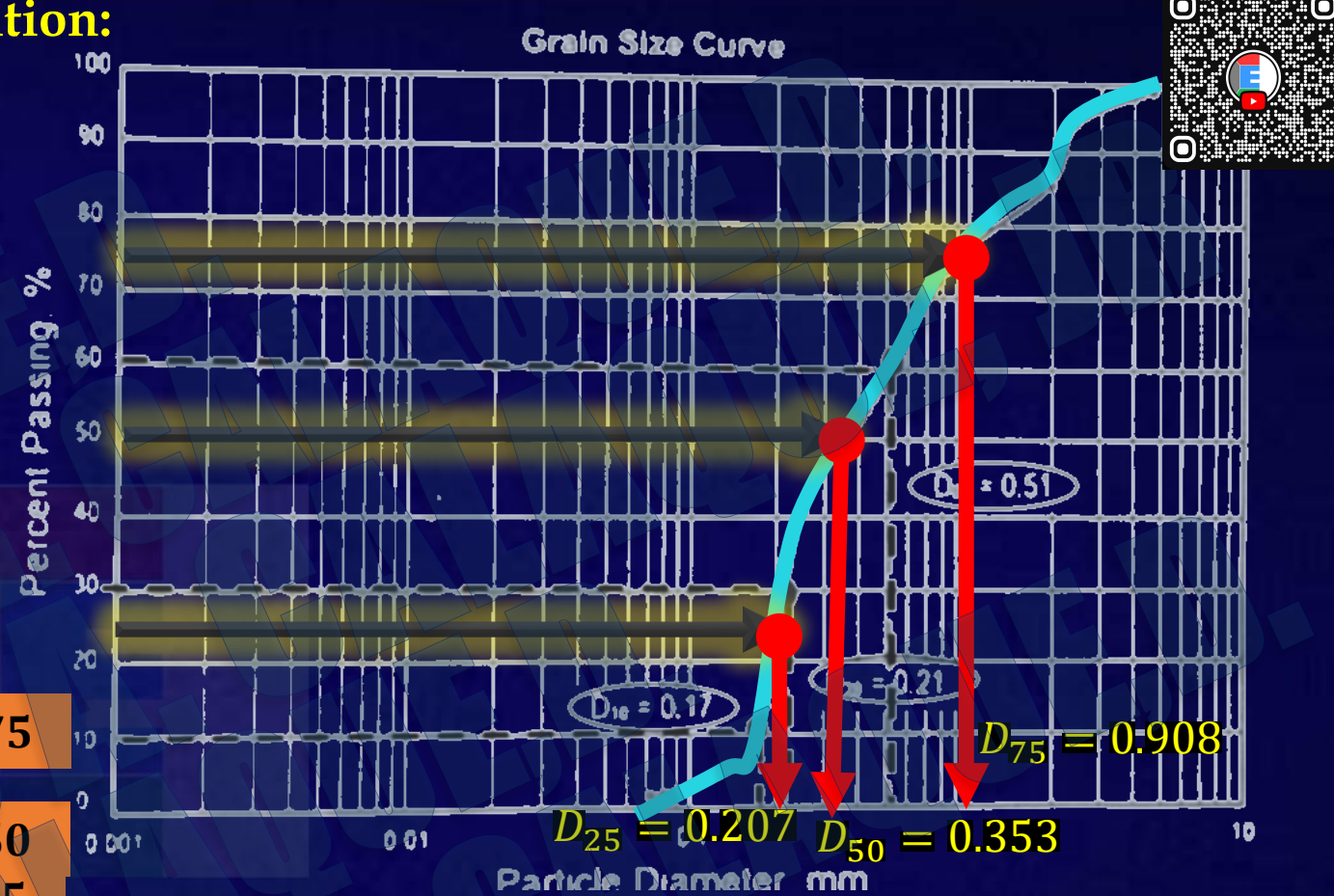
- a) Effective Diameter
- b) Average Grain Size
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- d) Coefficient of Gradation or Curvature
- e) Sorting Coefficient

Sieve No.	Diameter of Opening, mm	Percent Finer, %
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20	0.84	73.96
40	0.42	54.84
60	0.25	40.38
80	0.180	13.71
100	0.149	5.79
200	0.074	1.76
PAN	-	0

Gravel = 0.63%
Sand = 97.61%
Silt and Clay = 1.76%

Solution:

D75
D50
D25



Sorting Coefficient:

$$S_0 = \sqrt{\frac{D_{75}}{D_{25}}}$$
$$S_0 = \sqrt{\frac{D_{75}}{D_{25}}} = \sqrt{\frac{0.908}{0.207}} = 2.094$$

SOIL CLASSIFICATION ACCORD. TO USDA

PAST CE BOARD EXAM:

The result of the sieve analysis is shown below.
Classify the soil according to USDA

Gravel = **0.63%**

Sand = **97.61%**

Silt and Clay = **1.76%**

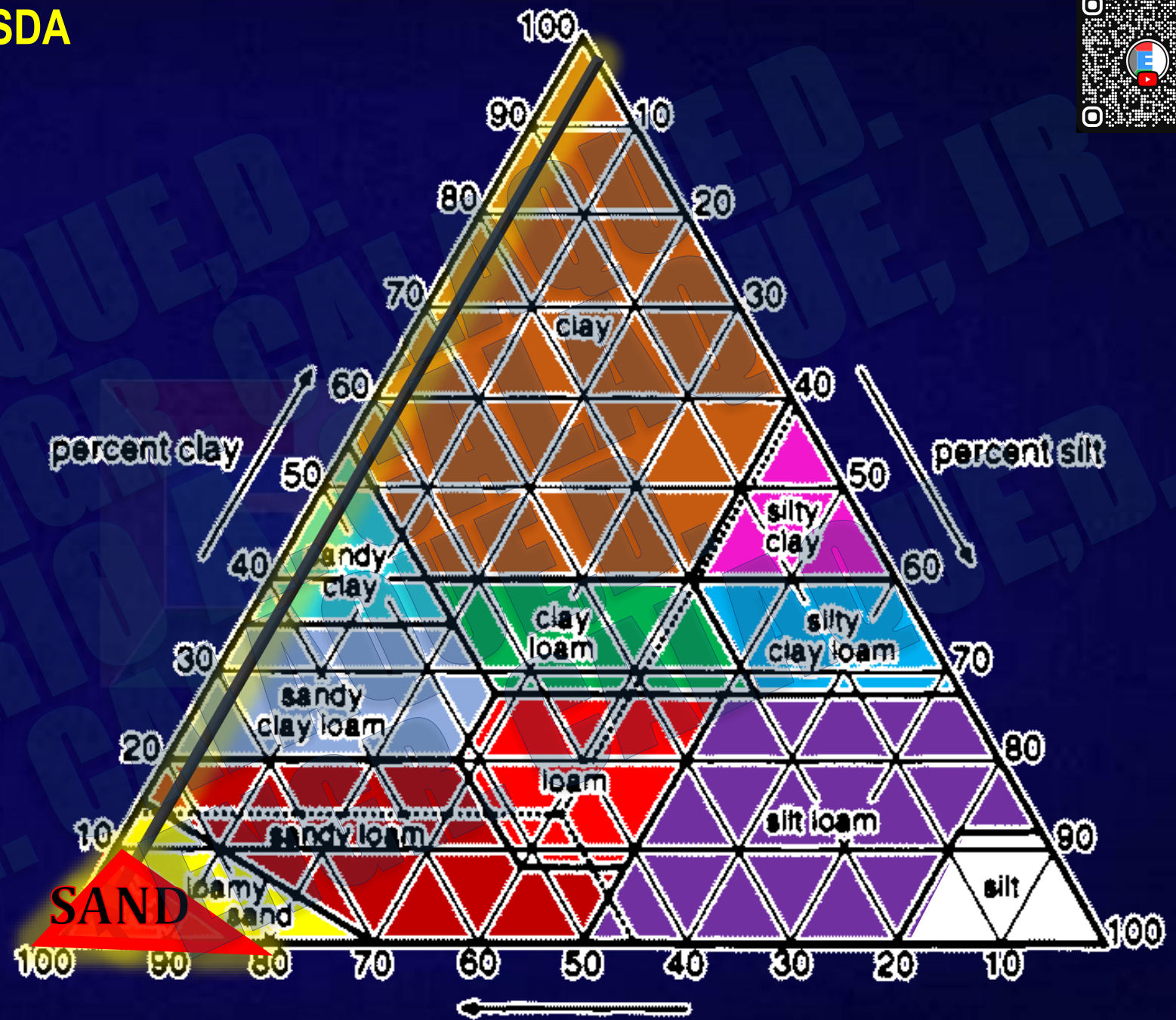
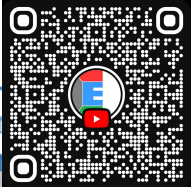


Table 5.2 Unified Soil Classification System (Based on Material Passing 76.2-mm Sieve)



Criteria for assigning group symbols

Coarse-grained soils More than 50% retained on No. 200 sieve	Gravels More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines ^a	$C_u \geq 4$ and $1 \leq C_c \leq 3^c$ $C_u < 4$ and/or $C_c < 1$ or $C_c > 3^c$	GW GP
		Gravels with Fines More than 12% fines ^{a,d}	$PI < 4$ or plots below "A" line (Figure 5.3) $PI > 7$ and plots on or above "A" line (Figure 5.3)	GM GC
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines ^b	$C_u \geq 6$ and $1 \leq C_c \leq 3^c$ $C_u < 6$ and/or $C_c < 1$ or $C_c > 3^c$	SW SP
		Sands with Fines More than 12% fines ^{b,d}	$PI < 4$ or plots below "A" line (Figure 5.3) $PI > 7$ and plots on or above "A" line (Figure 5.3)	SM SC
	Silts and clays Liquid limit less than 50	Inorganic	$PI > 7$ and plots on or above "A" line (Figure 5.3) ^e $PI < 4$ or plots below "A" line (Figure 5.3) ^e	CL ML
		Organic	$\frac{\text{Liquid limit} - \text{oven dried}}{\text{Liquid limit} - \text{not dried}} < 0.75$; see Figure 5.3; OL zone	OL
Fine-grained soils 50% or more passes No. 200 sieve	Silts and clays Liquid limit 50 or more	Inorganic	PI plots on or above "A" line (Figure 5.3) PI plots below "A" line (Figure 5.3)	CH MH
		Organic	$\frac{\text{Liquid limit} - \text{oven dried}}{\text{Liquid limit} - \text{not dried}} < 0.75$; see Figure 5.3; OH zone	OH
Highly organic soils	Primarily organic matter, dark in color, and organic odor			Pt

^aGravels with 5 to 12% fine require dual symbols: GW-GM, GW-GC, GP-GM, GP-GC.

^bSands with 5 to 12% fines require dual symbols: SW-SM, SW-SC, SP-SM, SP-SC.

$$^c C_u = \frac{D_{60}}{D_{10}}; \quad C_c = \frac{(D_{30})^2}{D_{60} \times D_{10}}$$

^dIf $4 \leq PI \leq 7$ and plots in the hatched area in Figure 5.3, use dual symbol GC-GM or SC-SM.



PAST CE BOARD EXAM:

The result of the sieve analysis is shown below. Classify the soil according to USCS

Solution:

$D_{10} = 0.17$
 $D_{30} = 0.21$
 $D_{60} = 0.51$
 $C_u = 3$
 $C_c = 0.509$

Step 1: Choose between (Coarse vs. Fines)?

Compute the Coarse Percentage, it is the Percentage Retained in No. 200 Sieve:

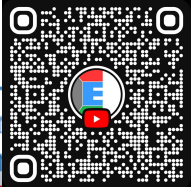
$$= 100\% - (P_{200})$$
$$= 100\% - 1.76\% = 98.24\%$$

Thus, since Coarse Percentage 98.24% is more than 50% → COARSE GRAINED SOILS

Sieve No.	Diameter of Opening, mm	Percent Finer, %
4	4.76	99.37
8	2.38	93.71
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20	0.84	73.96
40	0.42	54.84
60	0.25	40.38
80	0.180	13.71
100	0.149	5.79
200	0.074	1.76
PAN	-	0

SAND(USCS&AASHTO)

Table 5.2 Unified Soil Classification System (Based on Material Passing 76.2-mm Sieve)



Criteria for assigning group symbols

Coarse-grained soils
More than 50% retained on No. 200 sieve

Gravels More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines ^a	$C_u \geq 4$ and $1 \leq C_c \leq 3^c$ $C_u < 4$ and/or $C_c < 1$ or $C_c > 3^c$	GW GP
	Gravels with Fines More than 12% fines ^{a,d}	$PI < 4$ or plots below "A" line (Figure 5.3) $PI > 7$ and plots on or above "A" line (Figure 5.3)	GM GC
Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines ^b	$C_u \geq 6$ and $1 \leq C_c \leq 3^c$ $C_u < 6$ and/or $C_c < 1$ or $C_c > 3^c$	SW SP
	Sands with Fines More than 12% fines ^{b,d}	$PI < 4$ or plots below "A" line (Figure 5.3) $PI > 7$ and plots on or above "A" line (Figure 5.3)	SM SC

Fine-grained soils
50% or more passes No. 200 sieve

Silts and clays Liquid limit less than 50	Inorganic	$PI > 7$ and plots on or above "A" line (Figure 5.3) ^e $PI < 4$ or plots below "A" line (Figure 5.3) ^e	CL ML
	Organic	$\frac{\text{Liquid limit—oven dried}}{\text{Liquid limit—not dried}} < 0.75$; see Figure 5.3; OL zone	OL
Silts and clays Liquid limit 50 or more	Inorganic	PI plots on or above "A" line (Figure 5.3) PI plots below "A" line (Figure 5.3)	CH MH
	Organic	$\frac{\text{Liquid limit—oven dried}}{\text{Liquid limit—not dried}} < 0.75$; see Figure 5.3; OH zone	OH

Highly organic soils	Primarily organic matter, dark in color, and organic odor	Pt
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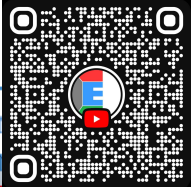
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^dIf $4 \leq PI \leq 7$ and plots in the hatched area in Figure 5.3, use dual symbol GC-GM or SC-SM.

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Criteria for assigning group symbols

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	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines ^b	$C_u \geq 6$ and $1 \leq C_c \leq 3^c$ $C_u < 6$ and/or $C_c < 1$ or $C_c > 3^c$	SW SP
		Sands with Fines More than 12% fines ^{b,d}	$PI < 4$ or plots below "A" line (Figure 5.3) $PI > 7$ and plots on or above "A" line (Figure 5.3)	SM SC
	Silts and clays Liquid limit less than 50	Inorganic	$PI > 7$ and plots on or above "A" line (Figure 5.3) ^e $PI < 4$ or plots below "A" line (Figure 5.3) ^e	CL ML
		Organic	$\frac{\text{Liquid limit} - \text{oven dried}}{\text{Liquid limit} - \text{not dried}} < 0.75$; see Figure 5.3; OL zone	OL
	Silts and clays Liquid limit 50 or more	Inorganic	PI plots on or above "A" line (Figure 5.3) PI plots below "A" line (Figure 5.3)	CH MH
		Organic	$\frac{\text{Liquid limit} - \text{oven dried}}{\text{Liquid limit} - \text{not dried}} < 0.75$; see Figure 5.3; OH zone	OH
Highly organic soils	Primarily organic matter, dark in color, and organic odor			Pt

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$$^c C_u = \frac{D_{60}}{D_{10}}; \quad C_c = \frac{(D_{30})^2}{D_{60} \times D_{10}}$$

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The result of the sieve analysis is shown below. Classify the soil according to USCS

Solution:

$D_{10} = 0.17$

$D_{30} = 0.21$

$D_{60} = 0.51$

$C_u = 3$

$C_c = 0.509$

Step 1: Choose between (Coarse vs. Fines)?
Compute the Coarse Percentage, it is the Percentage Retained in No. 200 Sieve:
 $= 100\% - (P_{200})$
 $= 100\% - 1.76\% = 98.24\%$

Thus, since Coarse Percentage 98.24% is more than 50% → COARSE GRAINED SOILS

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80	0.180	13.71
100	0.149	5.79
200	0.074	1.76
PAN	-	0

SAND(USCS)

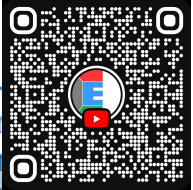
SAND(USCS &AASHTO)

Step 2: Choose between (Gravel vs. Sands)?

Compute the Gravel Percentage, it is the Percentage Retained in No. 4 Sieve:
 $= 100\% - (P_4)$
 $= 100\% - 99.37\% = 0.63\%$

Thus, since Gravel Percentage 0.63% is less than 50% → SANDS

Table 5.2 Unified Soil Classification System (Based on Material Passing 76.2-mm Sieve)



Criteria for assigning group symbols				
Coarse-grained soils More than 50% retained on No. 200 sieve	Gravels	Clean Gravels Less than 5% fines ^a	$C_u \geq 4$ and $1 \leq C_c \leq 3^c$ $C_u < 4$ and/or $C_c < 1$ or $C_c > 3^c$	GW GP
		Gravels with Fines More than 12% fines ^{a,d}	$PI < 4$ or plots below "A" line (Figure 5.3) $PI > 7$ and plots on or above "A" line (Figure 5.3)	GM GC
	Sands	Clean Sands Less than 5% fines ^b	$C_u \geq 6$ and $1 \leq C_c \leq 3^c$ $C_u < 6$ and/or $C_c < 1$ or $C_c > 3^c$	SW SP
		Sands with Fines More than 12% fines ^{b,d}	$PI < 4$ or plots below "A" line (Figure 5.3) $PI > 7$ and plots on or above "A" line (Figure 5.3)	SM SC
	Silts and clays	Inorganic	$PI > 7$ and plots on or above "A" line (Figure 5.3) ^e $PI < 4$ or plots below "A" line (Figure 5.3) ^e	CL ML
		Organic	<u>Liquid limit—oven dried</u> Liquid limit—not dried	OL
Fine-grained soils 50% or more passes No. 200 sieve			< 0.75 ; see Figure 5.3; OL zone	
	Silts and clays	Inorganic	PI plots on or above "A" line (Figure 5.3) PI plots below "A" line (Figure 5.3)	CH MH
		Organic	<u>Liquid limit—oven dried</u> Liquid limit—not dried	OH
			< 0.75 ; see Figure 5.3; OH zone	
Highly organic soils	Primarily organic matter, dark in color, and organic odor			Pt

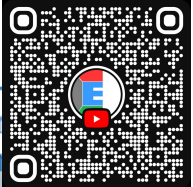
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^dIf $4 \leq PI \leq 7$ and plots in the hatched area in Figure 5.3, use dual symbol GC-GM or SC-SM.

Table 5.2 Unified Soil Classification System (Based on Material Passing 76.2-mm Sieve)



Criteria for assigning group symbols

Coarse-grained soils More than 50% retained on No. 200 sieve	Gravels More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines ^a	$C_u \geq 4$ and $1 \leq C_c \leq 3^c$ $C_u < 4$ and/or $C_c < 1$ or $C_c > 3^c$	GW GP
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	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines ^b	$C_u \geq 6$ and $1 \leq C_c \leq 3^c$ $C_u < 6$ and/or $C_c < 1$ or $C_c > 3^c$	SW SP
		Sands with Fines More than 12% fines ^{b,d}	$PI < 4$ or plots below “A” line (Figure 5.3) $PI > 7$ and plots on or above “A” line (Figure 5.3)	SM SC
Fine-grained soils 50% or more passes No. 200 sieve	Silts and clays Liquid limit less than 50	Inorganic	$PI > 7$ and plots on or above “A” line (Figure 5.3) ^e $PI < 4$ or plots below “A” line (Figure 5.3) ^e	CL ML
		Organic	$\frac{\text{Liquid limit—oven dried}}{\text{Liquid limit—not dried}} < 0.75$; see Figure 5.3; OL zone	OL
	Silts and clays Liquid limit 50 or more	Inorganic	PI plots on or above “A” line (Figure 5.3) PI plots below “A” line (Figure 5.3)	CH MH
		Organic	$\frac{\text{Liquid limit—oven dried}}{\text{Liquid limit—not dried}} < 0.75$; see Figure 5.3; OH zone	OH
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$$^c C_u = \frac{D_{60}}{D_{10}}; \quad C_c = \frac{(D_{30})^2}{D_{60} \times D_{10}}$$

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$D_{10} = 0.17$

$D_{30} = 0.21$

$D_{60} = 0.51$

$C_u = 3$

$C_c = 0.509$

Step 1: Choose between (Coarse vs. Fines)?
Compute the Coarse Percentage, it is the Percentage Retained in No. 200 Sieve:
 $= 100\% - (P_{200})$
 $= 100\% - 1.76\% = 98.24\%$
Thus, since Coarse Percentage 98.24% is more than 50% → COARSE GRAINED SOILS

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PAN	-	0

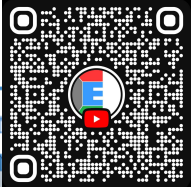
SAND(USCS)

Step 2: Choose between (Gravel vs. Sands)?
Compute the Gravel Percentage, it is the Percentage Retained in No. 4 Sieve:
 $= 100\% - (P_4)$
 $= 100\% - 99.37\% = 0.63\%$
Thus, since Gravel Percentage 0.63% is less than 50% → SANDS

SAND(USCS &AASHTO)

Step 3: Choose between (Clean Sands vs. Sands with Fines)?
The Fines is Percentage Passing No. 200 Sieve: $= 1.76\%$
Thus, since the Fines 1.76 % is less than 5% → CLEAN SANDS

Table 5.2 Unified Soil Classification System (Based on Material Passing 76.2-mm Sieve)



Criteria for assigning group symbols

Coarse-grained soils
More than 50% retained on No. 200 sieve

Gravels More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines ^a	$C_u \geq 4$ and $1 \leq C_c \leq 3^c$ $C_u < 4$ and/or $C_c < 1$ or $C_c > 3^c$	GW GP
	Gravels with Fines More than 12% fines ^{a,d}	$PI < 4$ or plots below "A" line (Figure 5.3) $PI > 7$ and plots on or above "A" line (Figure 5.3)	GM GC
	Clean Sands Less than 5% fines ^b	$C_u \geq 6$ and $1 \leq C_c \leq 3^c$ $C_u < 6$ and/or $C_c < 1$ or $C_c > 3^c$	SW SP
	Sands with Fines More than 12% fines ^{b,d}	$PI < 4$ or plots below "A" line (Figure 5.3) $PI > 7$ and plots on or above "A" line (Figure 5.3)	SM SC
Fine-grained soils 50% or more passes No. 200 sieve	Silts and clays Liquid limit less than 50	Inorganic $PI > 7$ and plots on or above "A" line (Figure 5.3) ^e $PI < 4$ or plots below "A" line (Figure 5.3) ^e	CL ML
		<u>Liquid limit—oven dried</u> Liquid limit—not dried	OL
	Silts and clays Liquid limit 50 or more	Organic PI plots on or above "A" line (Figure 5.3) PI plots below "A" line (Figure 5.3)	CH MH
		<u>Liquid limit—oven dried</u> Liquid limit—not dried	OH
		< 0.75 ; see Figure 5.3; OL zone	
		< 0.75 ; see Figure 5.3; OH zone	
	Highly organic soils	Primarily organic matter, dark in color, and organic odor	Pt

^aGravels with 5 to 12% fine require dual symbols: GW-GM, GW-GC, GP-GM, GP-GC.

^bSands with 5 to 12% fines require dual symbols: SW-SM, SW-SC, SP-SM, SP-SC.

$$^c C_u = \frac{D_{60}}{D_{10}}; \quad C_c = \frac{(D_{30})^2}{D_{60} \times D_{10}}$$

^dIf $4 \leq PI \leq 7$ and plots in the hatched area in Figure 5.3, use dual symbol GC-GM or SC-SM.



PAST CE BOARD EXAM:

The result of the sieve analysis is shown below. Classify the soil according to USCS

Solution:

$D_{10} = 0.17$

$D_{30} = 0.21$

$D_{60} = 0.51$

$C_u = 3$

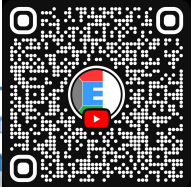
$C_c = 0.509$

Sieve No.	Diameter of Opening, mm	Percent Finer, %
4	4.76	99.37
8	2.38	93.71
10	2.00	85.53
20	0.84	73.96
40	0.42	54.84
60	0.25	40.38
80	0.180	13.71
100	0.149	5.79
200	0.074	1.76
PAN	-	0

$C_u (3) \geq 6$ [*false*] and $C_c(0.509) > 1$ [*false*] both not satisfied

$C_u (3) < 6$ [*true*] and $C_c(0.509) < 1$ [*true*] both are satisfied → **SP**

Table 5.2 Unified Soil Classification System (Based on Material Passing 76.2-mm Sieve)



Criteria for assigning group symbols

Coarse-grained soils
More than 50% retained on No. 200 sieve

Gravels More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines ^a	$C_u \geq 4$ and $1 \leq C_c \leq 3^c$ $C_u < 4$ and/or $C_c < 1$ or $C_c > 3^c$	GW GP
	Gravels with Fines More than 12% fines ^{a,d}	$PI < 4$ or plots below "A" line (Figure 5.3) $PI > 7$ and plots on or above "A" line (Figure 5.3)	GM GC
	Clean Sands Less than 5% fines ^b	$C_u \geq 6$ and $1 \leq C_c \leq 3^c$ $C_u < 6$ and/or $C_c < 1$ or $C_c > 3^c$	SW SP
	Sands with Fines More than 12% fines ^{b,d}	$PI < 4$ or plots below "A" line (Figure 5.3) $PI > 7$ and plots on or above "A" line (Figure 5.3)	SM SC
Fine-grained soils 50% or more passes No. 200 sieve	Silts and clays Liquid limit less than 50	Inorganic $PI > 7$ and plots on or above "A" line (Figure 5.3) ^e $PI < 4$ or plots below "A" line (Figure 5.3) ^e	CL ML
		<u>Liquid limit—oven dried</u> Liquid limit—not dried	OL
	Silts and clays Liquid limit 50 or more	Organic PI plots on or above "A" line (Figure 5.3) PI plots below "A" line (Figure 5.3)	CH MH
		<u>Liquid limit—oven dried</u> Liquid limit—not dried	OH
		< 0.75 ; see Figure 5.3; OL zone	
		< 0.75 ; see Figure 5.3; OH zone	
	Highly organic soils	Primarily organic matter, dark in color, and organic odor	Pt

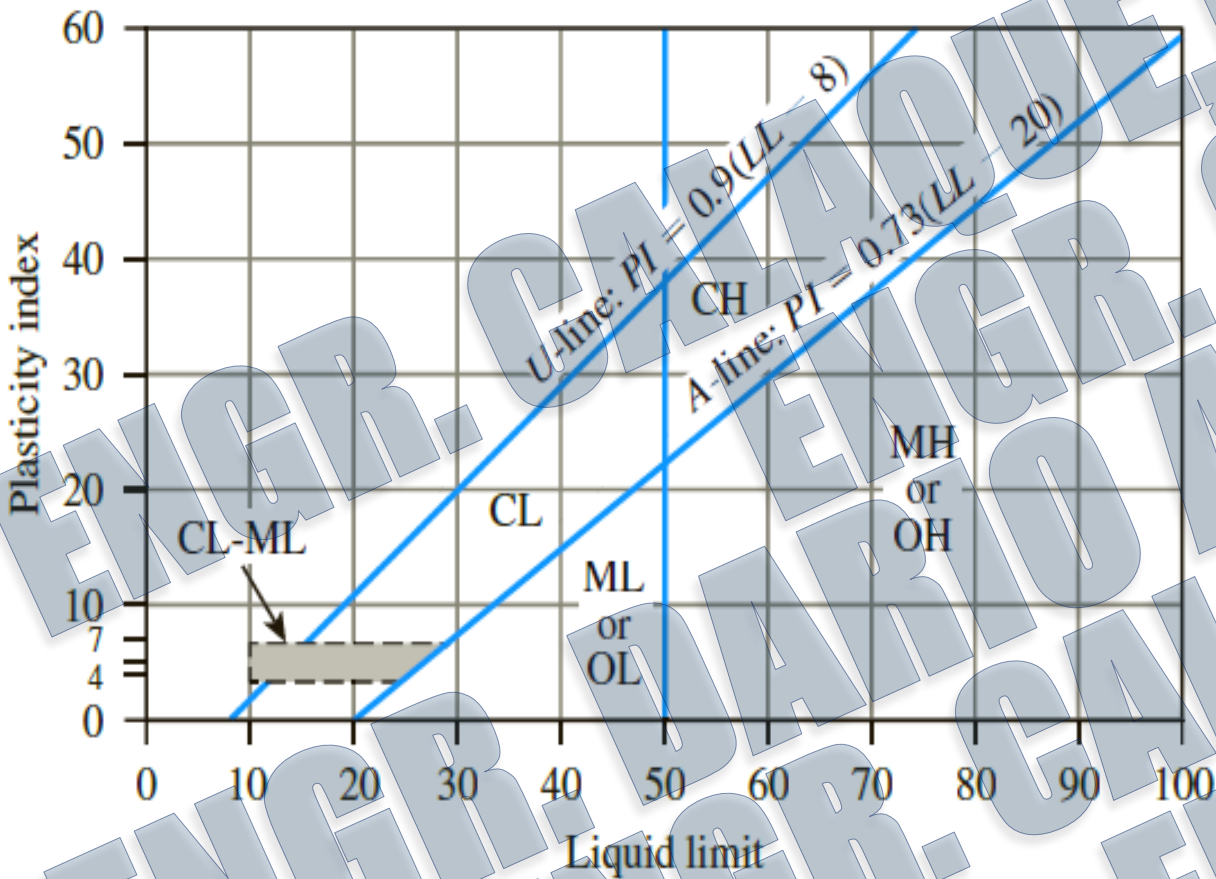
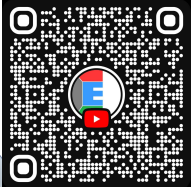
^aGravels with 5 to 12% fine require dual symbols: GW-GM, GW-GC, GP-GM, GP-GC.

^bSands with 5 to 12% fines require dual symbols: SW-SM, SW-SC, SP-SM, SP-SC.

$$^c C_u = \frac{D_{60}}{D_{10}}; \quad C_c = \frac{(D_{30})^2}{D_{60} \times D_{10}}$$

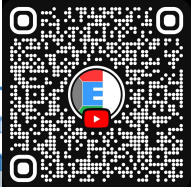
^dIf $4 \leq PI \leq 7$ and plots in the hatched area in Figure 5.3, use dual symbol GC-GM or SC-SM.

Unified Soil Classification System (USCS)



GW	<15% sand	Well-graded gravel
	≥15% sand	Well-graded gravel with sand
GP	<15% sand	Poorly graded gravel
	≥15% sand	Poorly graded gravel with sand
GW-GM	<15% sand	Well-graded gravel with silt
	≥15% sand	Well-graded gravel with silt and sand
GW-GC	<15% sand	Well-graded gravel with clay (or silty clay)
	≥15% sand	Well-graded gravel with clay and sand (or silty clay and sand)
GP-GM	<15% sand	Poorly graded gravel with silt
	≥15% sand	Poorly graded gravel with silt and sand
GP-GC	<15% sand	Poorly graded gravel with clay (or silty clay)
	≥15% sand	Poorly graded gravel with clay and sand (or silty clay and sand)
GM	<15% sand	Silty gravel
	≥15% sand	Silty gravel with sand
GC	<15% sand	Clayey gravel
	≥15% sand	Clayey gravel with sand
GC-GM	<15% sand	Silty clayey gravel
	≥15% sand	Silty clayey gravel with sand
SW	<15% gravel	Well-graded sand
	≥15% gravel	Well-graded sand with gravel
SP	<15% gravel	Poorly graded sand
	≥15% gravel	Poorly graded sand with gravel
SW-SM	<15% gravel	Well-graded sand with silt
	≥15% gravel	Well-graded sand with silt and gravel
SW-SC	<15% gravel	Well-graded sand with clay (or silty clay)
	≥15% gravel	Well-graded sand with clay and gravel (or silty clay and gravel)
SP-SM	<15% gravel	Poorly graded sand with silt
	≥15% gravel	Poorly graded sand with silt and gravel
SP-SC	<15% gravel	Poorly graded sand with clay (or silty clay)
	≥15% gravel	Poorly graded sand with clay and gravel (or silty clay and gravel)
SM	<15% gravel	Silty sand
	≥15% gravel	Silty sand with gravel
SC	<15% gravel	Clayey sand
	≥15% gravel	Clayey sand with gravel
SC-SM	<15% gravel	Silty clayey sand
	≥15% gravel	Silty clayey sand with gravel

Table 5.2 Unified Soil Classification System (Based on Material Passing 76.2-mm Sieve)



Criteria for assigning group symbols

Coarse-grained soils
More than 50% retained on No. 200 sieve

Gravels More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines ^a	$C_u \geq 4$ and $1 \leq C_c \leq 3^c$ $C_u < 4$ and/or $C_c < 1$ or $C_c > 3^c$	GW GP
	Gravels with Fines More than 12% fines ^{a,d}	$PI < 4$ or plots below "A" line (Figure 5.3) $PI > 7$ and plots on or above "A" line (Figure 5.3)	GM GC
Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines ^b	$C_u \geq 6$ and $1 \leq C_c \leq 3^c$ $C_u < 6$ and/or $C_c < 1$ or $C_c > 3^c$	SW SP
	Sands with Fines More than 12% fines ^{b,d}	$PI < 4$ or plots below "A" line (Figure 5.3) $PI > 7$ and plots on or above "A" line (Figure 5.3)	SM SC
Fine-grained soils 50% or more passes No. 200 sieve	Silts and clays Liquid limit less than 50	Inorganic $PI > 7$ and plots on or above "A" line (Figure 5.3) ^e $PI < 4$ or plots below "A" line (Figure 5.3) ^e	CL ML
		Liquid limit—oven dried Liquid limit—not dried < 0.75 ; see Figure 5.3; OL zone	OL
	Silts and clays Liquid limit 50 or more	Organic	
		Inorganic PI plots on or above "A" line (Figure 5.3) PI plots below "A" line (Figure 5.3)	CH MH
		Liquid limit—oven dried Liquid limit—not dried < 0.75 ; see Figure 5.3; OH zone	OH
		Organic	
Highly organic soils	Primarily organic matter, dark in color, and organic odor		Pt

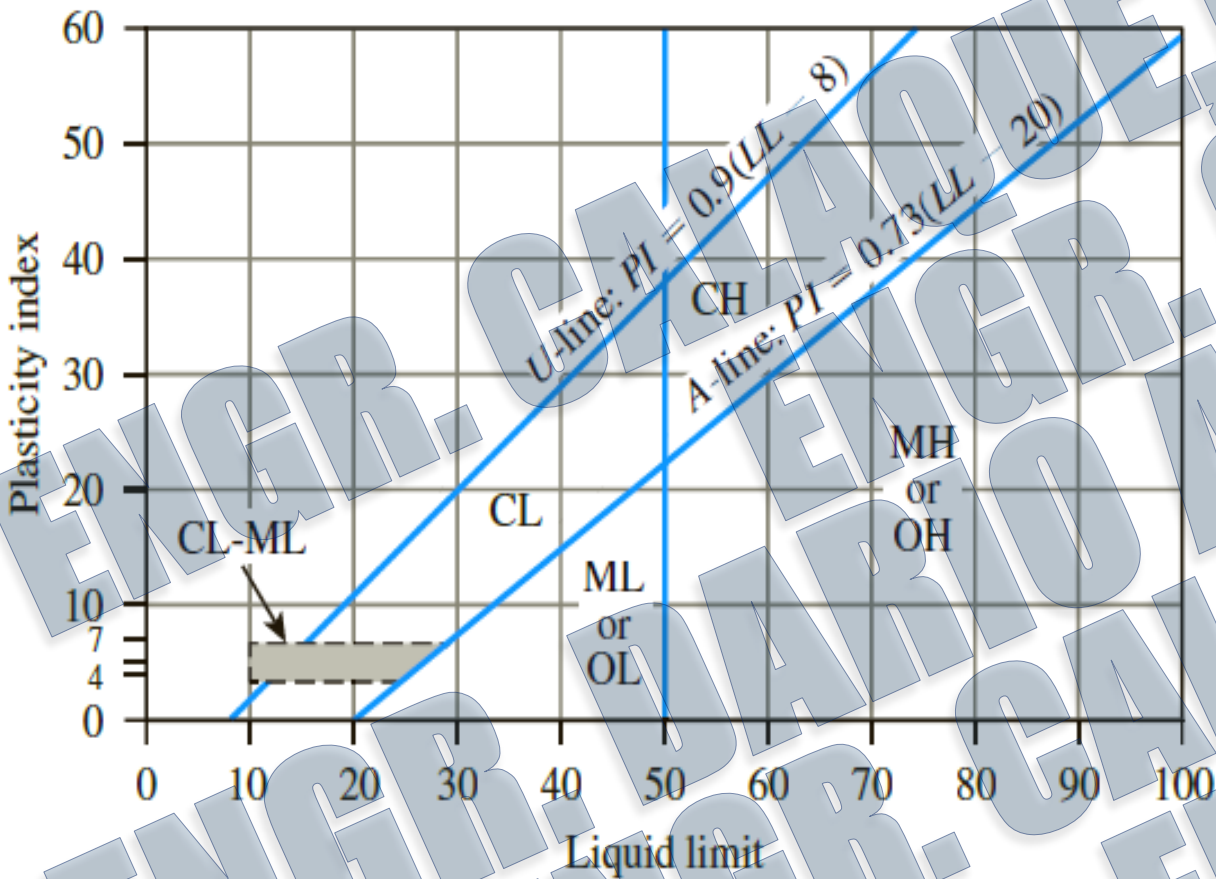
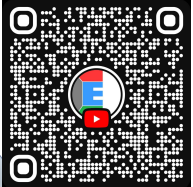
^aGravels with 5 to 12% fine require dual symbols: GW-GM, GW-GC, GP-GM, GP-GC.

^bSands with 5 to 12% fines require dual symbols: SW-SM, SW-SC, SP-SM, SP-SC.

$$^c C_u = \frac{D_{60}}{D_{10}}; \quad C_c = \frac{(D_{30})^2}{D_{60} \times D_{10}}$$

^dIf $4 \leq PI \leq 7$ and plots in the hatched area in Figure 5.3, use dual symbol GC-GM or SC-SM.

Unified Soil Classification System (USCS)



GW	<15% sand	Well-graded gravel
	≥15% sand	Well-graded gravel with sand
GP	<15% sand	Poorly graded gravel
	≥15% sand	Poorly graded gravel with sand
GW-GM	<15% sand	Well-graded gravel with silt
	≥15% sand	Well-graded gravel with silt and sand
GW-GC	<15% sand	Well-graded gravel with clay (or silty clay)
	≥15% sand	Well-graded gravel with clay and sand (or silty clay and sand)
GP-GM	<15% sand	Poorly graded gravel with silt
	≥15% sand	Poorly graded gravel with silt and sand
GP-GC	<15% sand	Poorly graded gravel with clay (or silty clay)
	≥15% sand	Poorly graded gravel with clay and sand (or silty clay and sand)
GM	<15% sand	Silty gravel
	≥15% sand	Silty gravel with sand
GC	<15% sand	Clayey gravel
	≥15% sand	Clayey gravel with sand
GC-GM	<15% sand	Silty clayey gravel
	≥15% sand	Silty clayey gravel with sand
SW	<15% gravel	Well-graded sand
	≥15% gravel	Well-graded sand with gravel
SP	<15% gravel	Poorly graded sand
	≥15% gravel	Poorly graded sand with gravel
SW-SM	<15% gravel	Well-graded sand with silt
	≥15% gravel	Well-graded sand with silt and gravel
SW-SC	<15% gravel	Well-graded sand with clay (or silty clay)
	≥15% gravel	Well-graded sand with clay and gravel (or silty clay and gravel)
SP-SM	<15% gravel	Poorly graded sand with silt
	≥15% gravel	Poorly graded sand with silt and gravel
SP-SC	<15% gravel	Poorly graded sand with clay (or silty clay)
	≥15% gravel	Poorly graded sand with clay and gravel (or silty clay and gravel)
SM	<15% gravel	Silty sand
	≥15% gravel	Silty sand with gravel
SC	<15% gravel	Clayey sand
	≥15% gravel	Clayey sand with gravel
SC-SM	<15% gravel	Silty clayey sand
	≥15% gravel	Silty clayey sand with gravel



PAST CE BOARD EXAM:

The result of the sieve analysis is shown below. Classify the soil according to USCS

Solution:

$D_{10} = 0.17$

$D_{30} = 0.21$

$D_{60} = 0.51$

$C_u = 3$

$C_c = 0.509$

Step 1: Choose between (Coarse vs. Fines)?
Compute the Coarse Percentage, it is the Percentage Retained in No. 200 Sieve:
 $= 100\% - (P_{200})$
 $= 100\% - 1.76\% = 98.24\%$

Thus, since Coarse Percentage 98.24% is more than 50% → COARSE GRAINED SOILS

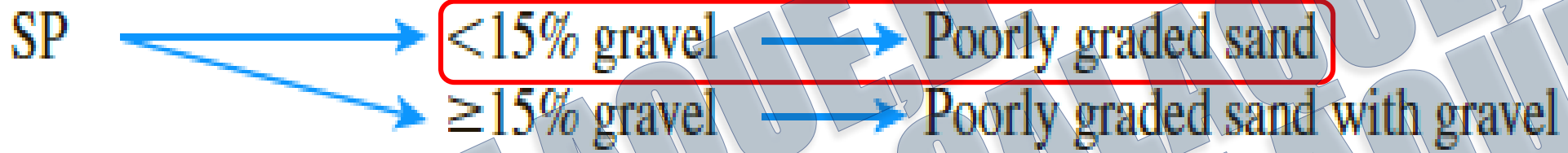
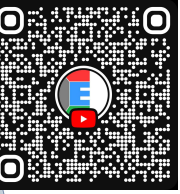
Sieve No.	Diameter of Opening, mm	Percent Finer, %
4	4.76	99.37
8	2.38	93.71
10	2.00	85.53
20	0.84	73.96
40	0.42	54.84
60	0.25	40.38
80	0.180	13.71
100	0.149	5.79
200	0.074	1.76
PAN	-	0

SAND(USCS)

SAND(USCS &AASHTO)

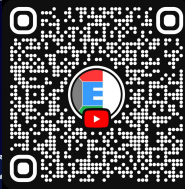
Step 2: Choose between (Gravel vs. Sands)?
Compute the Gravel Percentage, it is the Percentage Retained in No. 4 Sieve:
 $= 100\% - (P_4)$
 $= 100\% - 99.37\% = 0.63\%$
Thus, since Gravel Percentage 0.63% is less than 50% → SANDS

Step 5: Use Chart 3 for more complete description. Since SP and gravel percentage is 0.63%:



FINAL ANSWER:

SP (Poorly Graded Sand) Ans.



PAST CE BOARD EXAM:

The result of the sieve analysis is shown below. Classify the soil according to AASHTO

Take:
Liquid Limit = 30%
Plastic Limit = 20%

Solution:

$D_{10} = 0.17$
 $D_{30} = 0.21$
 $D_{60} = 0.51$
 $C_u = 3$
 $C_c = 0.509$

Sieve No.	Diameter of Opening, mm	Percent Finer, %
4	4.76	99.37
8	2.38	93.71
10	2.00	85.53
20	0.84	73.96
40	0.42	54.84
60	0.25	40.38
80	0.180	13.71
100	0.149	5.79
200	0.074	1.76
PAN	-	0

SAND(AASHTO)

SAND(USCS &AASHTO)

Percent Finer than No. 4 = 99.37 %
Percent Finer than No. 10 = 85.53 %
Percent Finer than No. 40 = 54.84 %
Percent Finer than No. 200 = 1.76 %
Liquid Limit = 30%
Plastic Limit = 20%
Plasticity Index
= Liquid Limit – Plastic Limit
= 30% - 20% = 10%

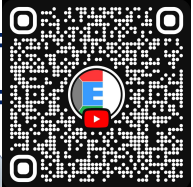
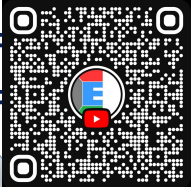


Table 5.1 Classification of Highway Subgrade Materials

General classification	Granular materials (35% or less of total sample passing No. 200)						
Group classification	~~A-1~~	~~A-1.5~~	A-3	A-2-4	A-2-5	A-2-6	A-2-7
Sieve analysis (percentage passing)							
No. 10	~~50 max.~~						
No. 40	30 max.	~~50 max.~~	51 min. ✓				
No. 200	15 max.	25 max.	10 max. ✓	35 max. ✓	35 max. ✓	35 max. ✓	35 max. ✓
Characteristics of fraction passing No. 40							
Liquid limit				40 max.	41 min.	40 max.	41 min.
Plasticity index		6 max.	NP	10 max.	10 max.	11 min.	11 min.
Usual types of significant constituent materials	Stone, fragments, gravel and sand		Fine sand	Silty or clayey gravel, and sand			
General subgrade rating	Excellent to good						

Percent Finer than No. 10 =
Percent Finer than No. 40 =
Percent Finer than No. 200 =



Silt-clay materials (more than 35% of total sample passing No. 200)				
General classification				
Group classification	~~A-4~~	~~A-5~~	~~A-6~~	~~A-7 A-7-5^a A-7-6^b~~
Sieve analysis (percentage passing)				
No. 10				
No. 40				
No. 200	~~36 min.~~	~~36 min.~~	~~36 min.~~	~~36 min.~~
Characteristics of fraction passing No. 40				
Liquid limit	40 max.	41 min.	40 max.	41 min.
Plasticity index	10 max.	10 max.	11 min.	11 min.
Usual types of significant constituent materials	Silty soils		Clayey soils	
General subgrade rating	Fair to poor			

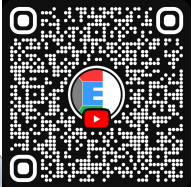
^aFor A-7-5, $PI \leq LL - 30$

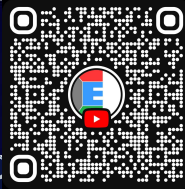
^bFor A-7-6, $PI > LL - 30$

Table 5.1 Classification of Highway Subgrade Materials

General classification	Granular materials (35% or less of total sample passing No. 200)						
Group classification	A-1	A-2	A-3	A-4	A-5	A-6	A-7
Sieve analysis (percentage passing)							
No. 10	50 max.	50 max.	51 min.	51 min.	51 min.	51 min.	51 min.
No. 40	30 max.	30 max.	30 max.	30 max.	30 max.	30 max.	30 max.
No. 200	15 max.	25 max.	10 max.	10 max.	10 max.	10 max.	10 max.
Characteristics of fraction passing No. 40							
Liquid limit					40 max.	40 max.	40 max.
Plasticity index					10 max.	10 max.	10 max.
Usual types of significant constituent materials	Stone, fragments, gravel and sand		Fine sand		Silty or clayey gravel, and sand		
General subgrade rating					Excellent to good		

Liquid Limit = 30%
Plastic Limit = 20%
Plasticity Index
= Liquid Limit – Plastic Limit
= 30% - 20% = 10%





PAST CE BOARD EXAM:

The result of the sieve analysis is shown below. Classify the soil according to AASHTO

Take:
Liquid Limit = 30%
Plastic Limit = 20%

Solution:

$D_{10} = 0.17$
 $D_{30} = 0.21$
 $D_{60} = 0.51$
 $C_u = 3$
 $C_c = 0.509$

Sieve No.	Diameter of Opening, mm	Percent Finer, %
4	4.76	99.37
8	2.38	93.71
10	2.00	85.53
20	0.84	73.96
40	0.42	54.84
60	0.25	40.38
80	0.180	13.71
100	0.149	5.79
200	0.074	1.76
PAN	-	0

SAND(AASHTO)

SAND(USCS &AASHTO)

Percent Finer than No. 4 = 99.37 %
Percent Finer than No. 10 = 85.53 %
Percent Finer than No. 40 = 54.84 %
Percent Finer than No. 200 = 1.76 %
Liquid Limit = 30%
Plastic Limit = 20%
Plasticity Index
= Liquid Limit – Plastic Limit
= 30% - 20% = 10%

Determine the GI.
The group index of soils belonging to groups *A-1-a*, *A-1-b*, *A-2-4*, *A-2-5*, and *A-3* is always 0.

Final Answer is: A- 2-4 (0)

PAST CE BOARD EXAM:

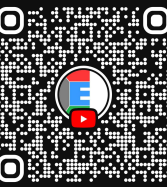
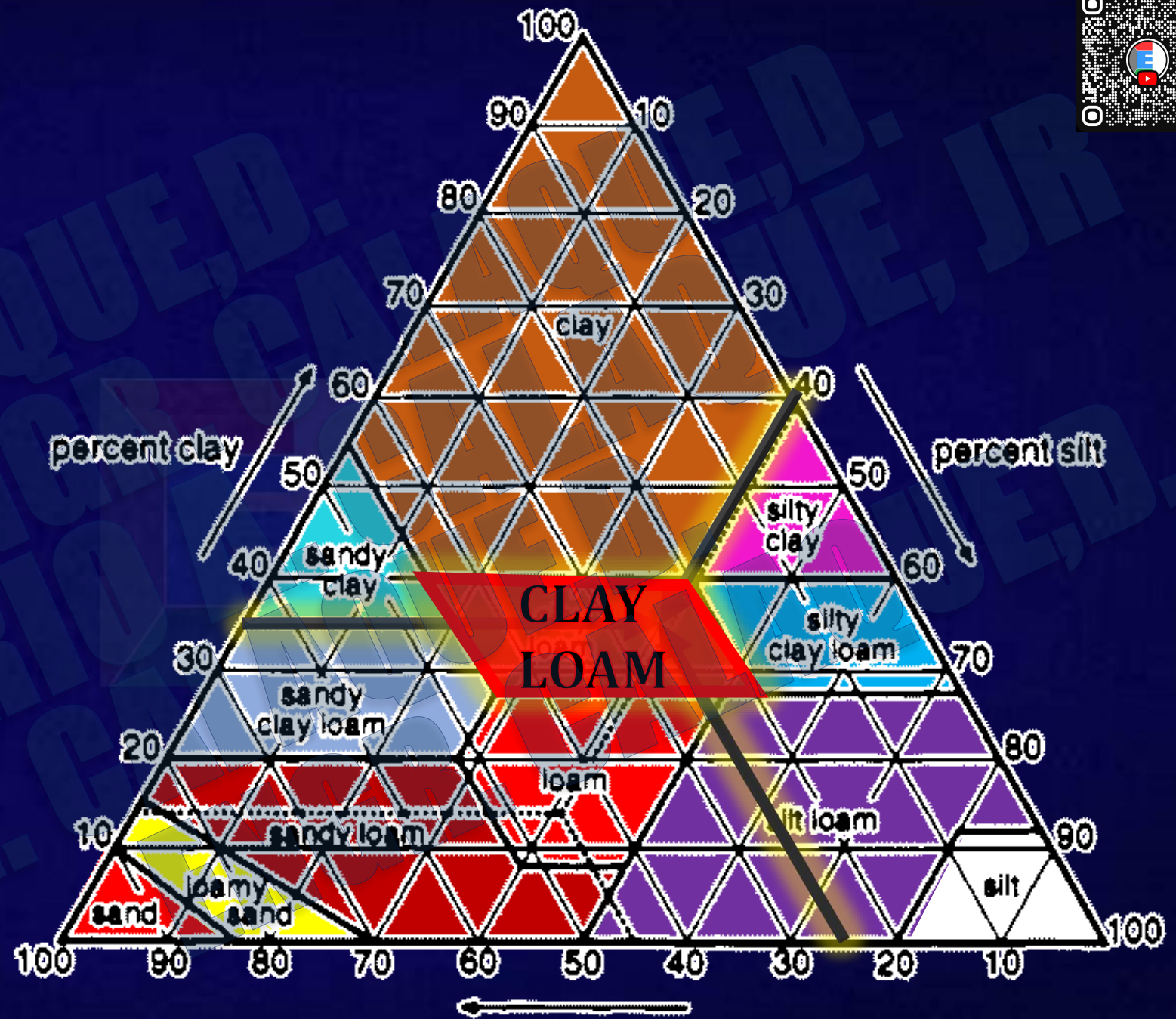
Classify the soil in accordance with USDA if the given soil is:

25% Sand

40% Silt

36% Clay

- A) LOAM
- B) CLAY LOAM
- C) CLAY
- D) SILT LOAM

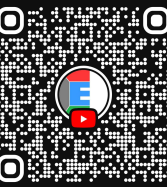
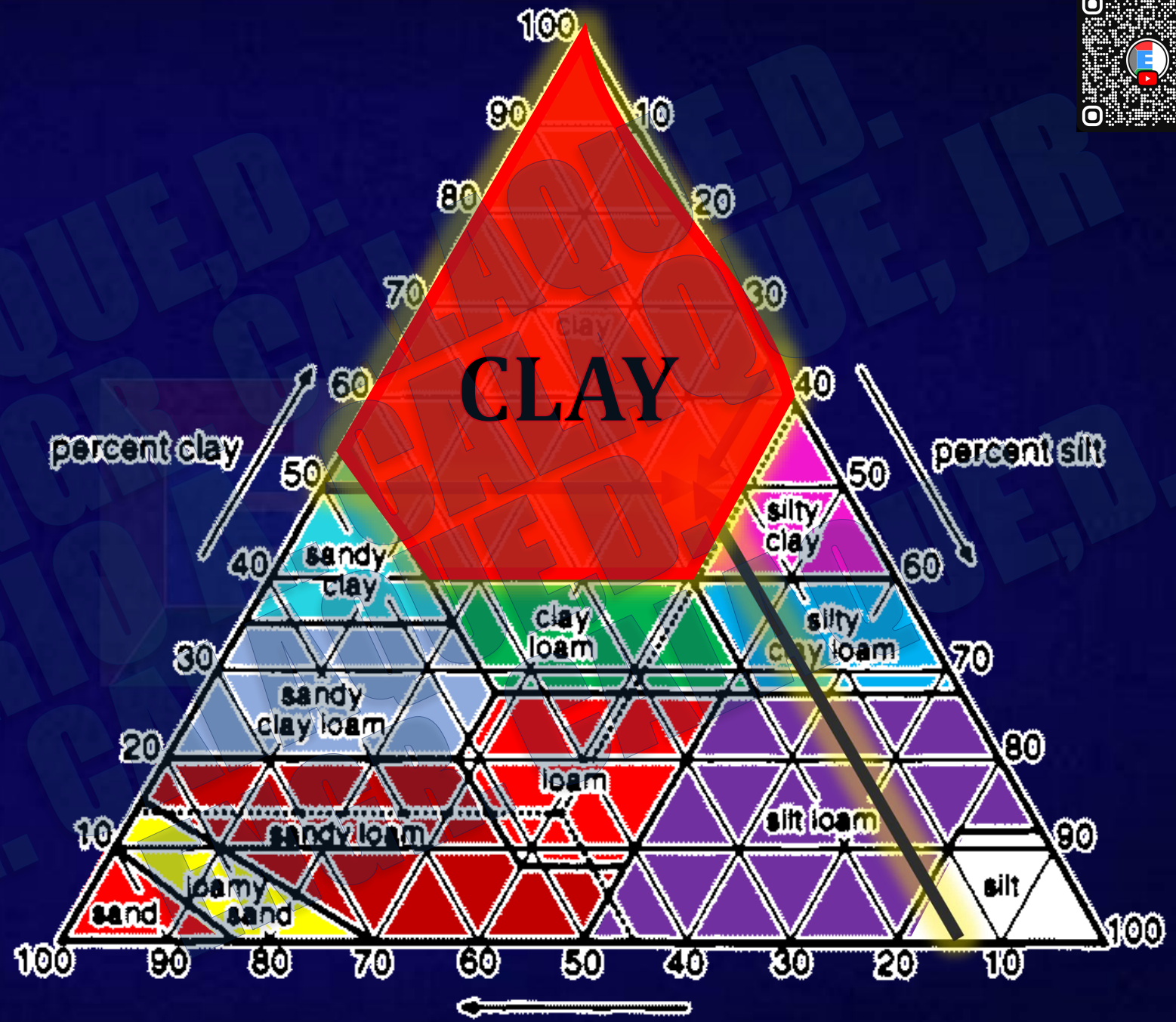


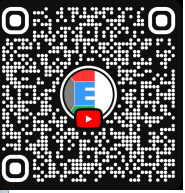
PAST CE BOARD EXAM:

From the percentage of sand, silt and clay, determine the soil classification using the USDA Method:

Sand = 12.5 % ;
Silt = 37.5%
and *Clay* = 50.0%

- A) LOAM
- B) CLAY LOAM
- C) CLAY
- D) SILT LOAM





PAST CE BOARD EXAM:
Classify the soil according to AASHTO:

Percentage Passing No. 4 = 95%
Percentage Passing No. 200 = 70%
Liquid Limit = 30%
Plastic Limit = 24%

- A) A-1-b
- B) A-4
- C) A-2-6
- D) A-7-6

Table 5.1 Classification of Highway Subgrade Materials

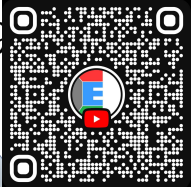
General classification	Granular materials (35% or less of total sample passing No. 200)						
Group classification	A-1		A-3	A-2			
	A-1-a	A-1-b		A-2-4	A-2-5	A-2-6	A-2-7
Sieve analysis (percentage passing)							
No. 10	50 max.						
No. 40	30 max.	50 max.	51 min.				
No. 200	15 max.	25 max.	10 max.	35 max.	35 max.	35 max.	35 max.
Characteristics of fraction passing No. 40							
Liquid limit				40 max.	41 min.	40 max.	41 min.
Plasticity index		6 max.	NP	10 max.	10 max.	11 min.	11 min.
Usual types of significant constituent materials	Stone, fragments, gravel and sand		Fine sand	Silty or clayey gravel, and sand			
General subgrade rating	Excellent to good						
General classification	Silt-clay materials (more than 35% of total sample passing No. 200)						
Group classification			A-4	A-5	A-6		A-7 A-7-5 ^a A-7-6 ^b
Sieve analysis (percentage passing)							
No. 10							
No. 40							
No. 200			36 min.	36 min.	36 min.		36 min.
Characteristics of fraction passing No. 40							
Liquid limit			40 max.	41 min.	40 max.		41 min.
Plasticity index			10 max.	10 max.	11 min.		11 min.
Usual types of significant constituent materials				Silty soils		Clayey soils	
General subgrade rating	Fair to poor						

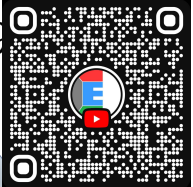
^aFor A-7-5, $PI \leq LL - 30$

Table 5.1 Classification of Highway Subgrade Materials

General classification	Granular materials (35% or less of total sample passing No. 200)						
	A-1			A-2			
Group classification	~~A-1-a~~	~~A-1-b~~	~~A-3~~	~~A-2-4~~	~~A-2-5~~	~~A-2-6~~	~~A-2-7~~
Sieve analysis (percentage passing)							
No. 10	50 max.						
No. 40	30 max.	50 max.	51 min.				
No. 200	~~15 max.~~	~~25 max.~~	~~10 max.~~	~~35 max.~~	~~35 max.~~	~~35 max.~~	~~35 max.~~
Characteristics of fraction passing No. 40							
Liquid limit				40 max.	41 min.	40 max.	41 min.
Plasticity index		6 max.	NP	10 max.	10 max.	11 min.	11 min.
Usual types of significant constituent materials	Stone, fragments, gravel and sand		Fine sand	Silty or clayey gravel, and sand			
General subgrade rating	Excellent to good						

Percentage Passing No. 4 = 90
Percentage Passing No. 200 = 10
Liquid Limit = 30%
Plastic Limit = 24%
PI = LL - PL = 6%





General classification

Silt-clay material
(more than 35% of total sample)

Group classification

A-4

~~A-5~~

~~A-6~~

~~A-7-5^a~~
~~A-7-6^b~~

Sieve analysis (percentage passing)

No. 10

No. 40

No. 200

✓ 36 min.

✓ 36 min.

✓ 36 min.

✓ 36 min.

Characteristics of fraction passing No. 40

Liquid limit

✓ 40 max.

~~41 min.~~

✓ 40 max.

~~41 min.~~

Plasticity index

✓ 10 max.

10 max.

~~11 min.~~

11 min.

Usual types of significant constituent materials

Silty soils

Clayey soils

General subgrade rating

Fair to poor

^aFor A-7-5, $PI \leq LL - 30$

^bFor A-7-6, $PI > LL - 30$

Step 2: Determine the GI.

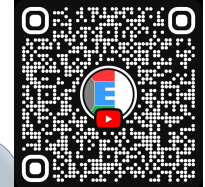
- For any other groups:

$$GI = (F_{200} - 35)[0.2 + 0.005(LL - 40)] + 0.01(F_{200} - 15)(PI - 10)$$

$$GI = (70 - 35)[0.2 + 0.005(30 - 40)] + 0.01(70 - 15)(6 - 10)$$

$$GI = 3.05 \cong 3$$

FINAL ANSWER: **A-4 (3)** **Ans.**



PAST CE BOARD EXAM:

Classify the soil according to AASHTO:

Percentage Passing No. 4 = 60%
Percentage Passing No. 200 = 37%
Liquid Limit = 45 %
Plastic Limit = 16%

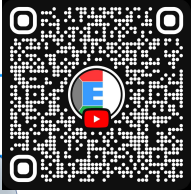
Plasticity Index = LL - PL = 45% - 16% = 29%

- A) A-1-b
- B) A-4
- C) A-2-6
- D) A-7-6

Table 5.1 Classification of Highway Subgrade Materials

General classification	Granular materials (35% or less of total sample passing No. 200)						
Group classification	A-1		A-3	A-2			
	A-1-a	A-1-b		A-2-4	A-2-5	A-2-6	A-2-7
Sieve analysis (percentage passing)							
No. 10	50 max.						
No. 40	30 max.	50 max.	51 min.				
No. 200	15 max.	25 max.	10 max.	35 max.	35 max.	35 max.	35 max.
Characteristics of fraction passing No. 40							
Liquid limit				40 max.	41 min.	40 max.	41 min.
Plasticity index		6 max.	NP	10 max.	10 max.	11 min.	11 min.
Usual types of significant constituent materials	Stone, fragments, gravel and sand		Fine sand	Silty or clayey gravel, and sand			
General subgrade rating	Excellent to good						
General classification	Silt-clay materials (more than 35% of total sample passing No. 200)						
Group classification			A-4	A-5	A-6		A-7 A-7-5 ^a A-7-6 ^b
Sieve analysis (percentage passing)							
No. 10							
No. 40							
No. 200			36 min.	36 min.	36 min.		36 min.
Characteristics of fraction passing No. 40							
Liquid limit			40 max.	41 min.	40 max.		41 min.
Plasticity index			10 max.	10 max.	11 min.		11 min.
Usual types of significant constituent materials				Silty soils	Clayey soils		
General subgrade rating	Fair to poor						

^aFor A-7-5, PI ≤ LL - 30



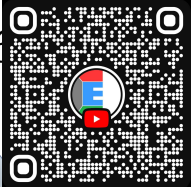


Table 5.1 Classification of Highway Subgrade Materials

General classification	Granular materials (35% or less of total sample passing No. 200)						
	A-1		A-2				
Group classification	~~A-1-a~~	~~A-1-b~~	~~A-2-1~~	~~A-2-4~~	~~A-2-5~~	~~A-2-6~~	~~A-2-7~~
Sieve analysis (percentage passing)							
No. 10	50 max.						
No. 40	30 max.	50 max.	51 min.				
No. 200	~~15 max.~~	~~25 max.~~	~~10 max.~~	~~35 max.~~	~~35 max.~~	~~35 max.~~	~~35 max.~~
Characteristics of fraction passing No. 40							
Liquid limit				40 max.	41 min.	40 max.	41 min.
Plasticity index		6 max.	NP	10 max.	10 max.	11 min.	11 min.
Usual types of significant constituent materials	Stone, fragments, gravel and sand		Fine sand	Silty or clayey gravel, and sand			
General subgrade rating	Excellent to good						

Percentage Passing No. 4 = 60 %
Percentage Passing No. 200 = 35 %
Liquid Limit = 45 %

Silt-clay materials
(more than 35% of total sample)

- Percentage Passing No. 200
- Liquid Limit = 45 %
- Plastic Limit = 16%
- Plasticity Index = $LL - PL = 29\%$

~~A-7~~ ~~A-7-5^a~~ ~~A-7-6^b~~ ✓ A-7-5^a A-7-6^b

No. 10

No. 40

No. 200

✓ 36 min.

✓ 36 min.

✓ 36 min.

✓ 36 min.

Liquid limit

~~40 max.~~

41 min.

~~40 max.~~

✓ 41 min.

Plasticity index

10 max.

~~10 max~~

11 min.

✓ 11 min.

Usual types of significant constituent materials

Silty soils

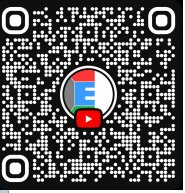
Clayey soils

General subgrade rating

Fair to poor

^aFor A-7-5, $PI \leq LL - 30$

^bFor A-7.6 $PI > 11 - 30$



But which should be used A-7-5 or A-7-6?

$$\begin{aligned}\text{Actual Plasticity Index} &= 29\% \stackrel{?}{>} LL - 30 \\ &= 29\% \stackrel{?}{>} 45 - 30\% \\ &= 29\% > 15\% \longrightarrow \text{A-7-6}\end{aligned}$$

Step 2: Determine the GI.

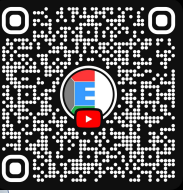
- For any other groups:

$$GI = (F_{200} - 35)[0.2 + 0.005(LL - 40)] + 0.01(F_{200} - 15)(PI - 10)$$

$$GI = (37 - 35)[0.2 + 0.005(45 - 40)] + 0.01(37 - 15)(29 - 10)$$

$$GI = 4.63 \cong 5$$

FINAL ANSWER: **A-7-6 (5)** **Ans.**



SITUATION 3:

From the following data of a given sieve analysis:

Sieve No.	Opening (mm)	Percent passing
#4	4.76	90
#8	2.38	64
#10	2.0	58
#25	0.71	30
#60	0.25	22
#100	0.149	10
#200	0.074	4

7. Determine the effective grain size (D_{10}).

- a. 0.20
- b. 0.15
- c. 2.0
- d. 0.09

8. Determine C_u .

- a. 10
- b. 15
- c. 20
- d. 5

SITUATION 4:

The following data shows the results of the sieve analysis of two soil samples A and B.

Sieve no.	Opening(mm)	Percent Passing	
		A	B
#4	4.76	90	100
#8	2.38	64	98
#10	2.0	58	90
#25	0.71	30	72
#60	0.25	22	45
#100	0.149	10	25
#200	0.074	4	0

9. Which of the following most nearly gives the uniformity coefficient for soil A.

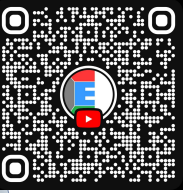
- a. 12
- b. 15
- c. 10
- d. 8

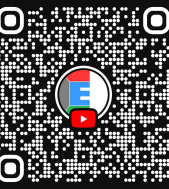
10. Classify the soil A using USCS method.

- a. well graded sand
- b. well graded gravel
- c. poorly graded sand
- d. poorly graded gravel

11. Classify the soil B using USCS method.

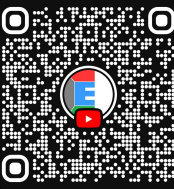
- a. well graded sand
- b. well graded gravel
- c. poorly graded sand
- d. poorly graded gravel





LET'S REVIEW SOIL CONSISTENCY

SOIL CONSISTENCY



Increasing Moisture Content = Wetting

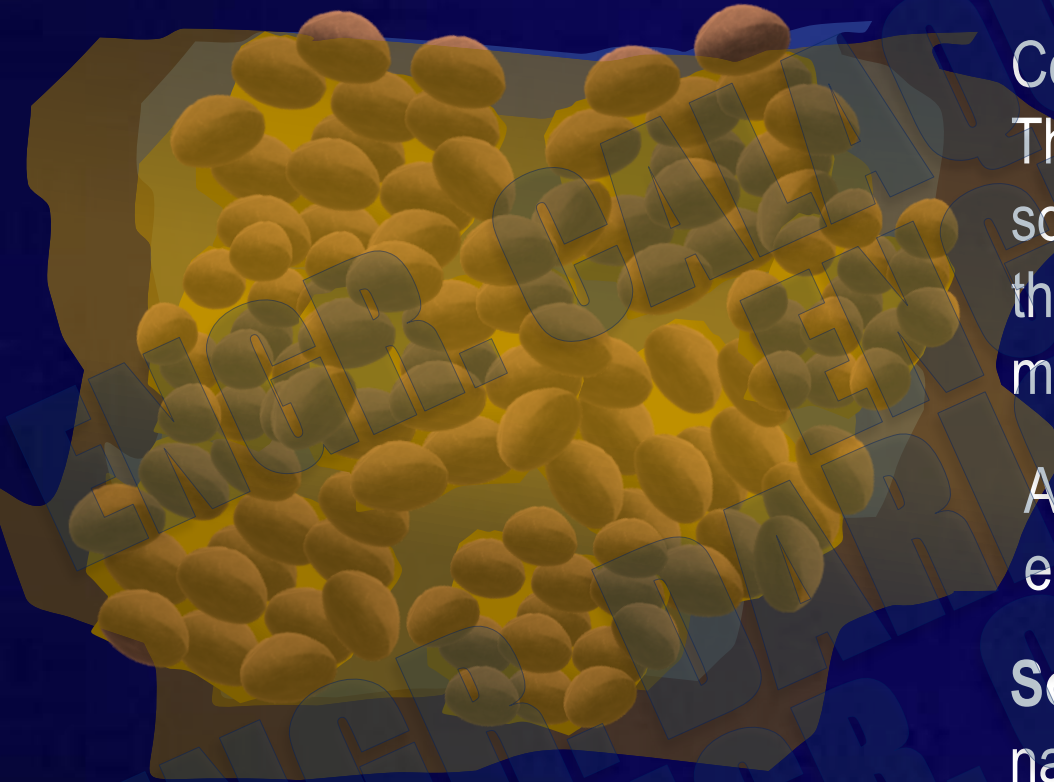
To Liquify

Solid State

Semi-Solid State

Plastic State

Liquid State



Consistency means, either the soil is hard, stiff, firm, or soft. This term is used mostly for fine grained soil. The fine grained soil can have plastic state when water is added to it, which then can take any shape given to it. Water reduces cohesion making it easier to mold.

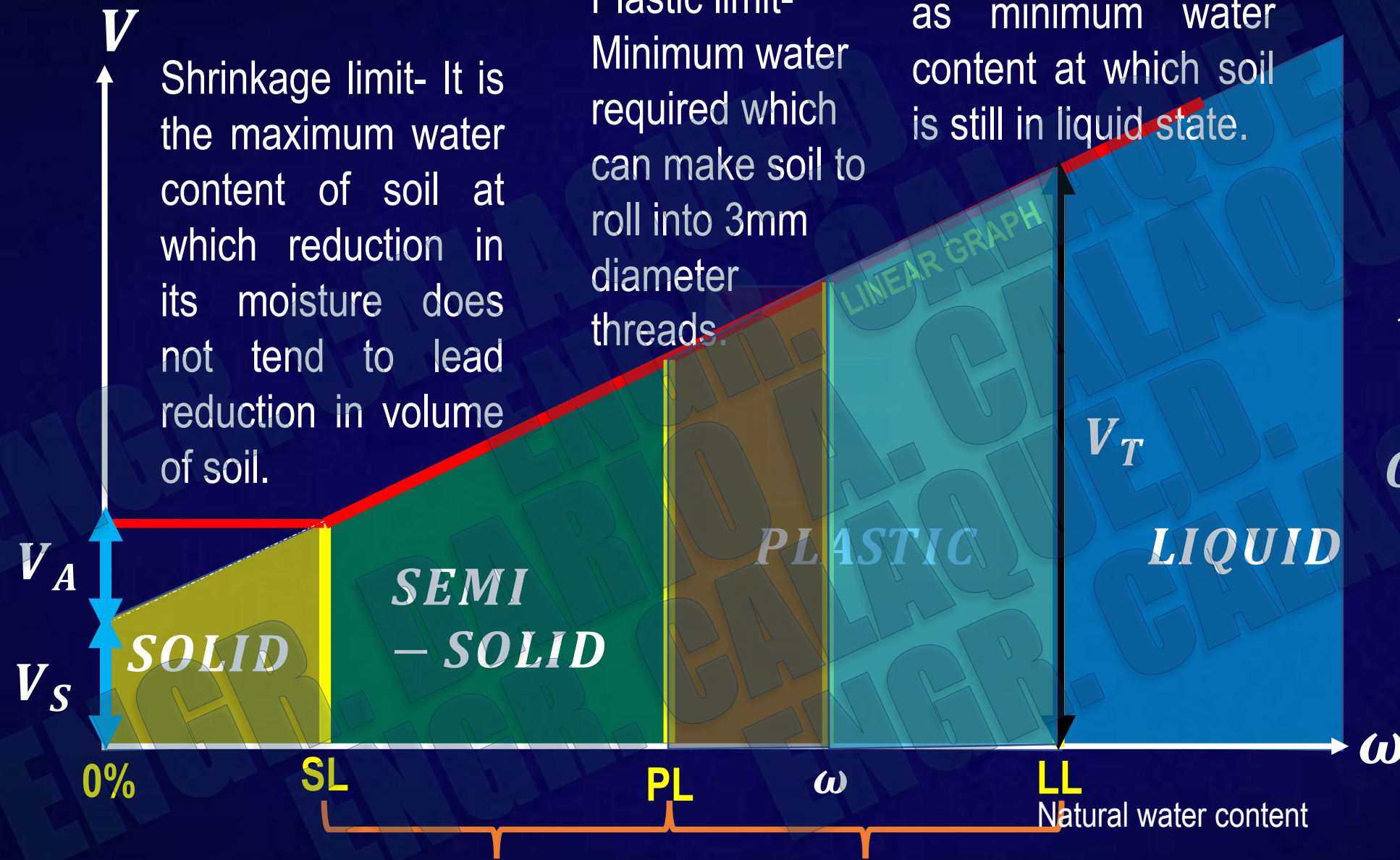
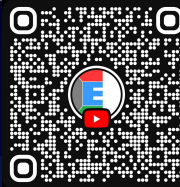
Atterberg limits - The atterberg limits most useful for the engineering purposes are liquid, plastic and shrinkage limit.

Soil Consistency expresses the state of compactness of a natural state.

To Shrink = Related To Soil Compaction

Decreasing Moisture Content = Drying

ATTERBERG'S LIMIT



Shrinkage limit- It is the maximum water content of soil at which reduction in its moisture does not tend to lead reduction in volume of soil.

Plastic limit- Minimum water required which can make soil to roll into 3mm diameter threads.

•Liquid limit- Defined as minimum water content at which soil is still in liquid state.

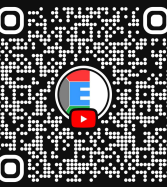
$$LI = \frac{\omega - PL}{LL - PL}$$

$$CI = \frac{LL - \omega}{LL - PL}$$

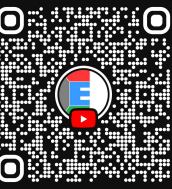
SL - PL SL PL - LL PL

SHRINKAGE LIMIT

- The shrinkage limit (SL) is defined as the moisture content at which the soil does not undergo any further change in volume with loss of moisture (ASTM Test Designation D-427).



SHRINKAGE LIMIT



- The shrinkage limit (SL) is defined as the moisture content at which the soil does not undergo any further change in volume with loss of moisture (ASTM Test Designation D-427).

$$SL = \frac{m_1 - m_2}{m_2} - \frac{v_1 - v_2}{m_2} \times \rho_w$$

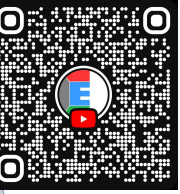
WHERE:

m_1, V_1 = mass of wet soil

m_2, V_2 = mass of oven dried soil

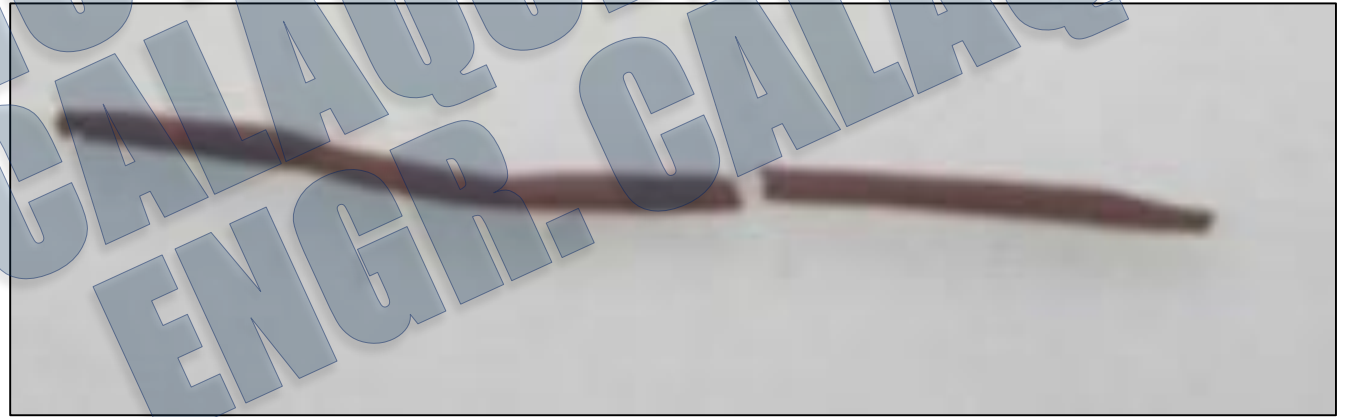
ρ_w = density of water = 1g/cc

PLASTIC LIMIT



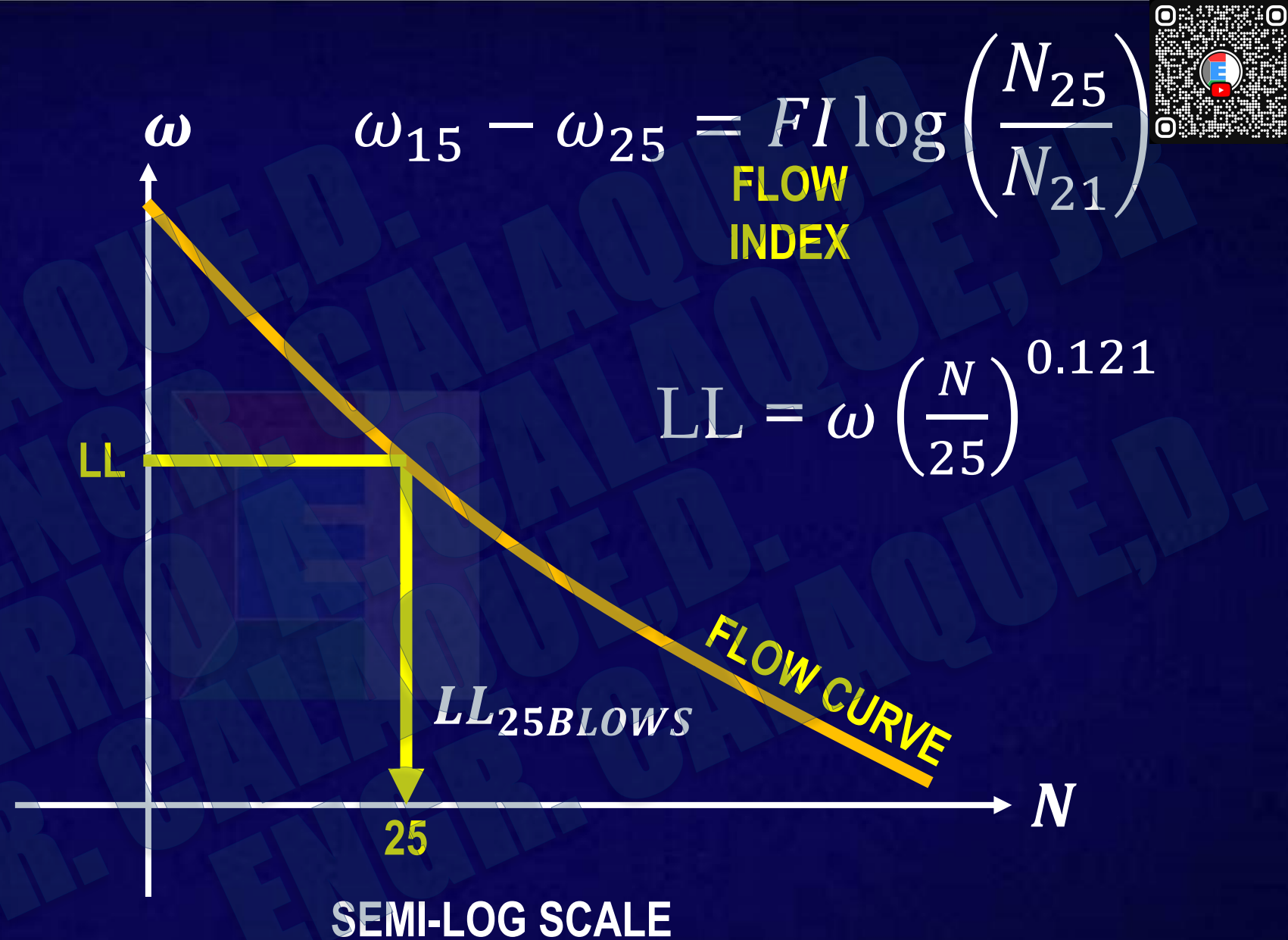
- The plastic limit (PL) is defined as the moisture content at which the soil crumbles when rolled into a thread of 3.18 mm (1/8 in.) in diameter (ASTM Test Designation D-4318).

d=3 mm

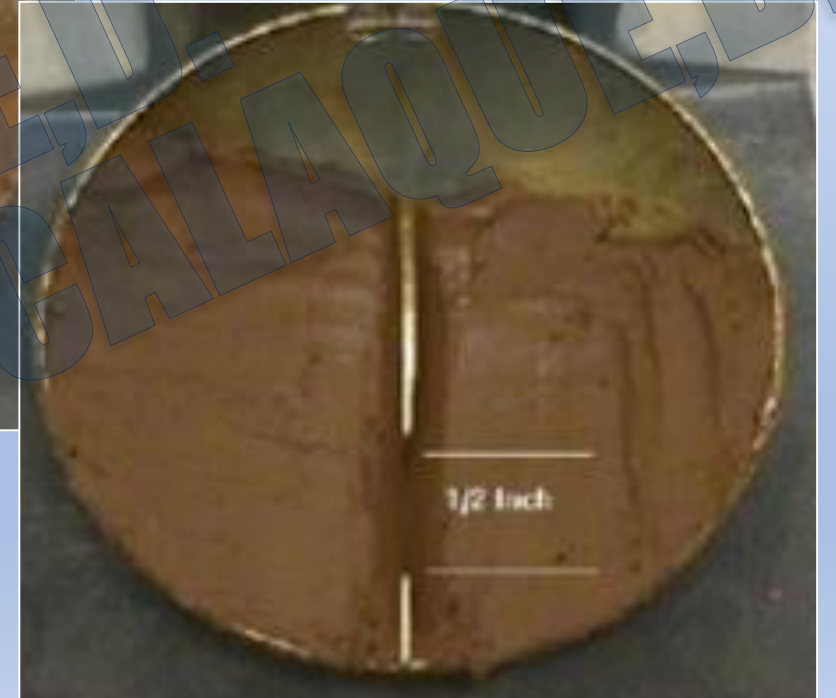
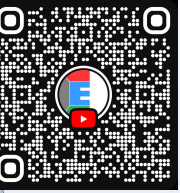


LIQUID LIMIT

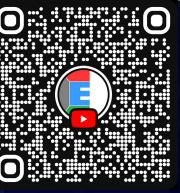
- The liquid limit of a soil (LL) is determined by Casagrande's liquid device (ASTM Test Designation D-4318) and is defined as the moisture content at which a groove closure of 12.7 mm (1/2 in.) occurs at 25 blows.



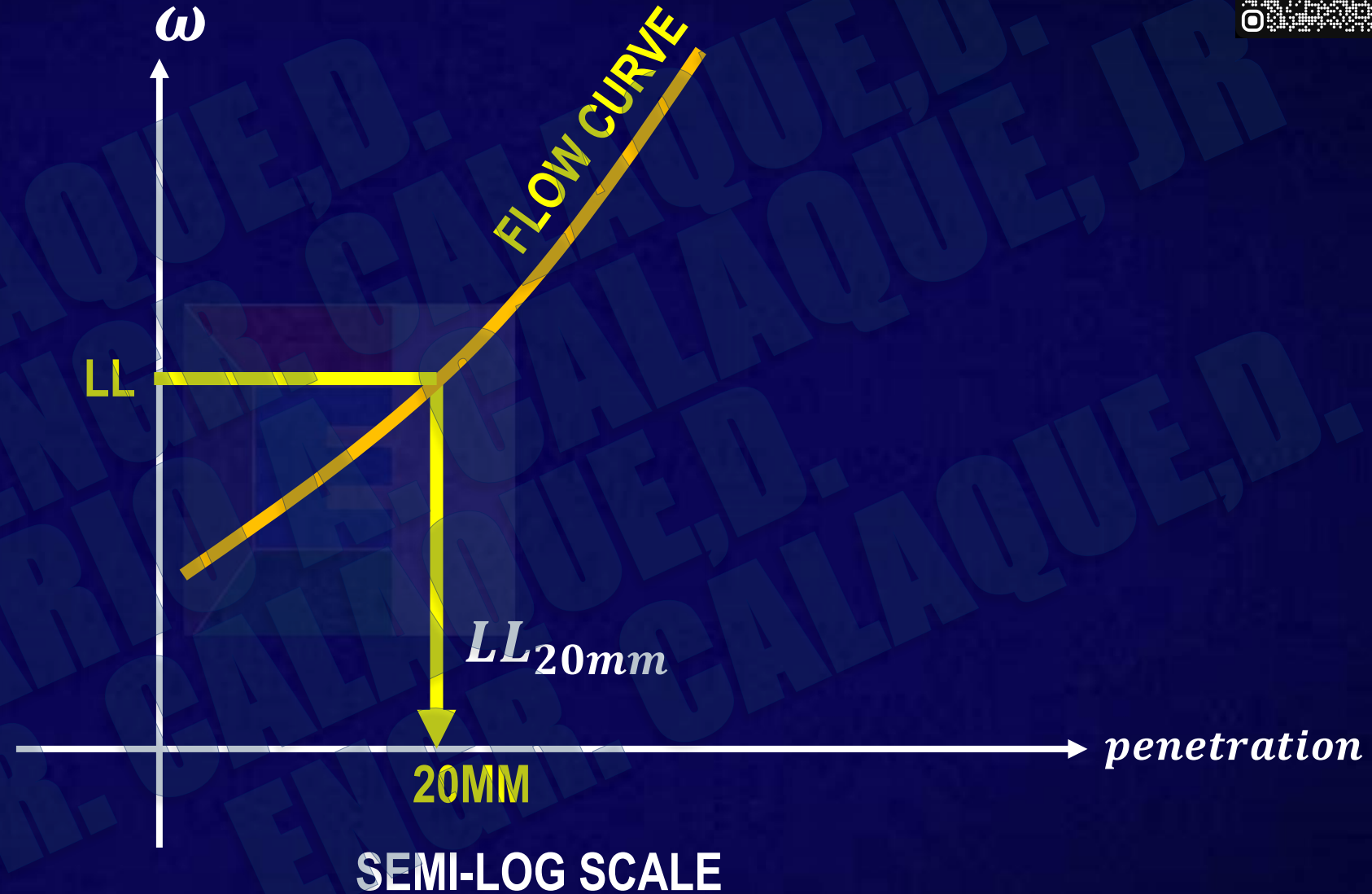
CASAGRANDE'S CUP METHOD



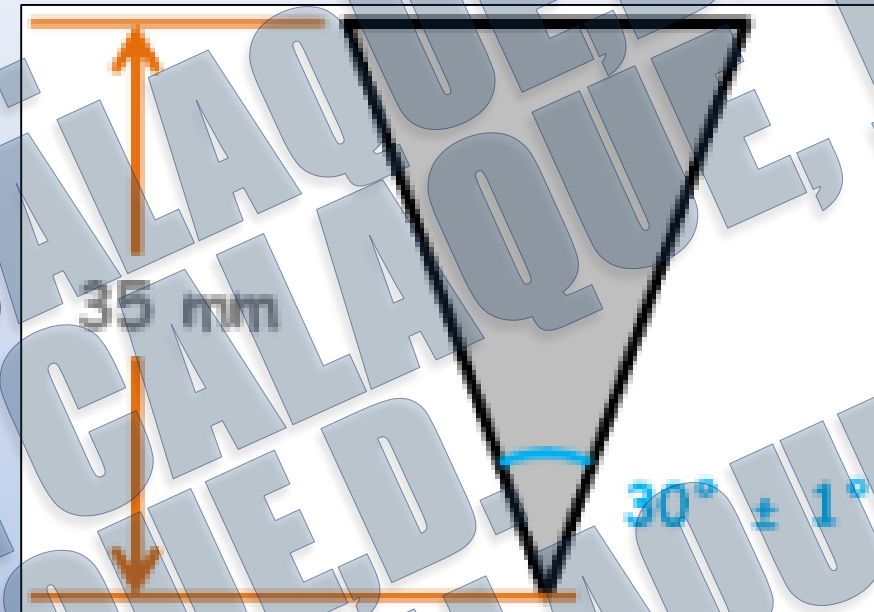
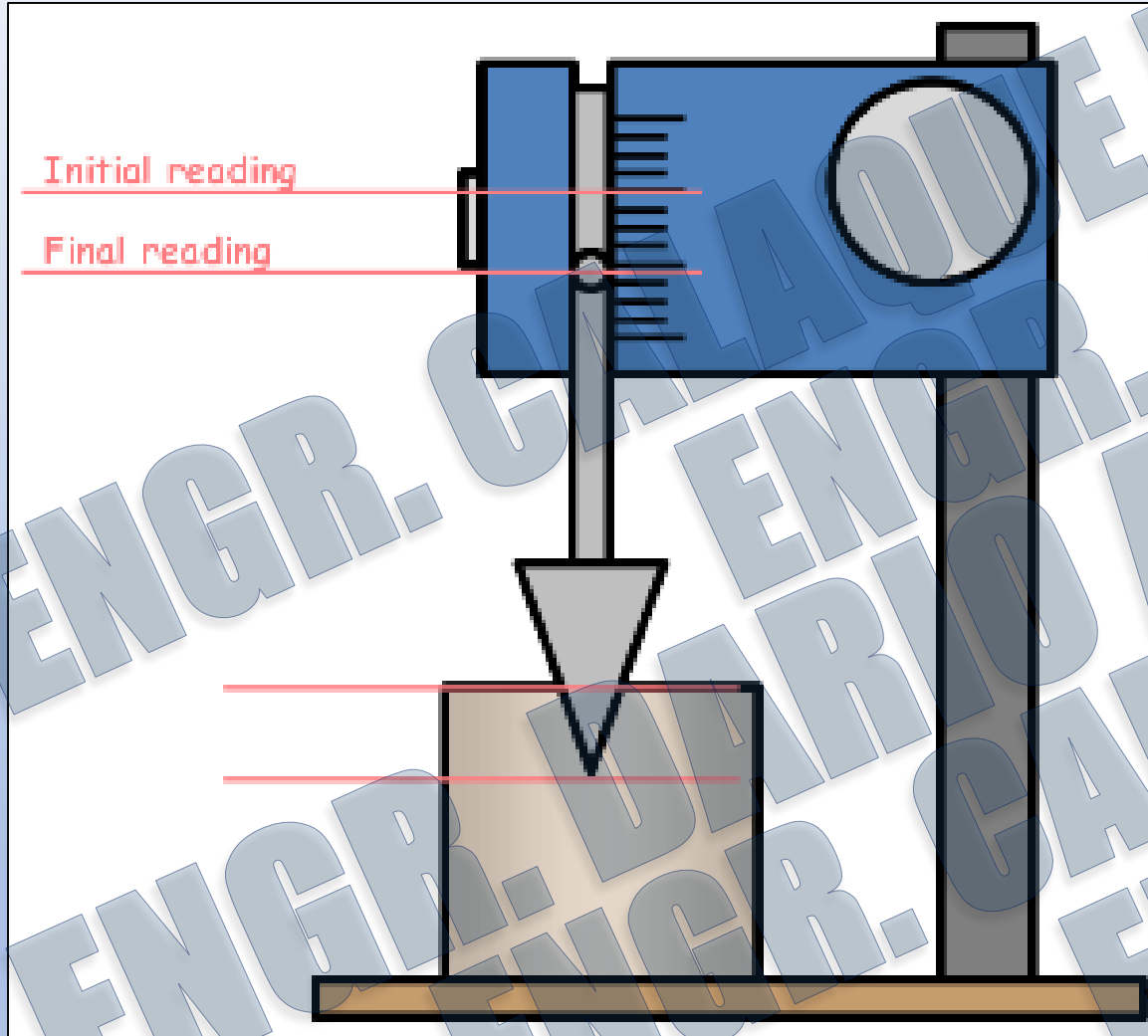
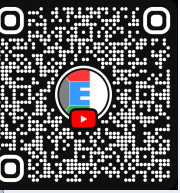
LIQUID LIMIT



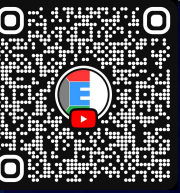
- Liquid limit of a particular soil is defined as the water content at which cone penetrates the soil up to 20 mm in 5 seconds



CONE PENETRATION TEST



ACTIVITY OF CLAY

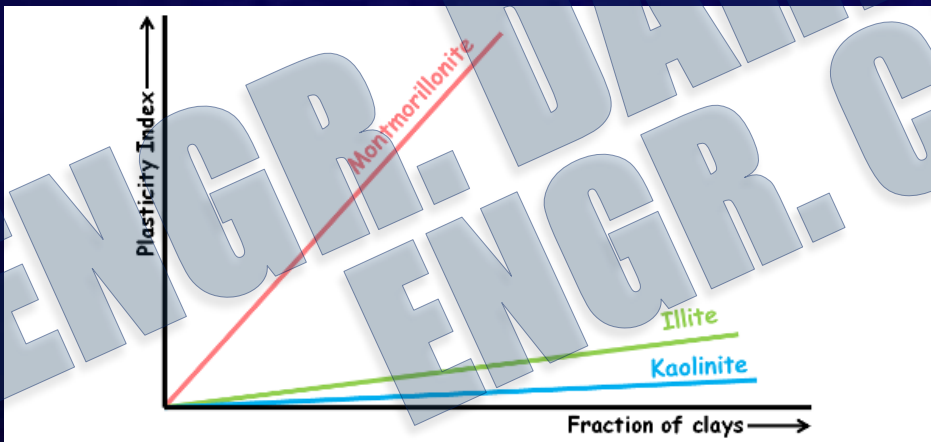


- Skempton defined a soil parameter which he called Activity of soil and defined as the ratio of plasticity index of a soil to the per cent of clay particles by weight in the soil.

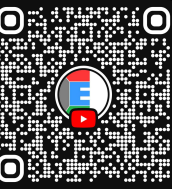
$$\text{Activity} = \frac{\text{Plasticity Index}}{\% \text{ clay fraction in soil}}$$

$$PI/\mu = A$$

Activity is a measure of water holding capacity of clayey soils



Activity	Soil Classification
< 0.75	Inactive
0.75 - 1.25	Normal Active
> 1.25	Active



SHRINKAGE INDEX

$$SI_{ya} = PL_a - S_e L_{osa}$$

Palambing rana!

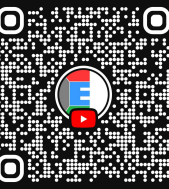
SHRINKAGE LIMIT

$$S_{eL_{ution}}^{osa} = \frac{m_1^{ara} - m_2^{ing}}{m_2^{oney}} - \frac{\rho_w^a (v_1^e - v_2^e)}{m_2^{odin!}}$$



LIQUIDITY INDEX (L.I) & PLASTICITY INDEX (P.I)

Pili wala ma pala | Pusang Iring Lalaki



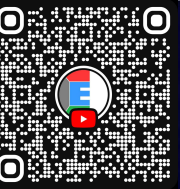
$$PILI = \omega_{ala} \overset{\text{minus}}{\overline{ma}} PL_a$$

$$P_{usang}^{utang} I_{ring}^{na} = LL_{aki} - PL_a$$

Mapapamura ka talaga!

Kakapili mo kasi!





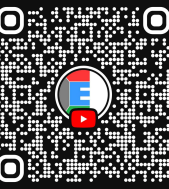
CONSISTENCY INDEX

$$CI = \frac{LL - \omega}{LL - PL} = \frac{LL - \omega}{PI}$$

PAG $LL^i - w_{ala\ n\ ay} = CIPI$
CP | Cellphone

Daghan kawatan!





ACTIVITY OF CLAY



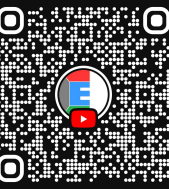
$$P_{ara} \underbrace{I/\mu}_{iyo} = A_{ng \text{ laban nato!}}$$

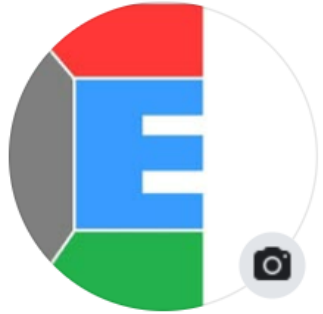




"HINDI KO ANAK YAN"
-MANNY PACQUIAO

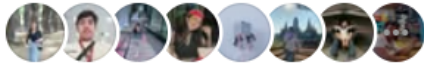






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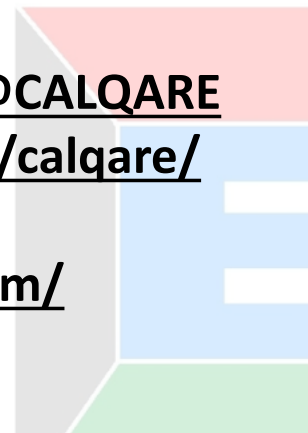


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